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ART. X.—*The Colorado Plateau Province as a Field for Geological Study;* by G. K. GILBERT.

[Continued from page 24.]

[It has happened that the division of this paper into parts has interrupted the sense, and I shall therefore have to ask the reader who would understand this page to refer again to the figures on page 23 of this volume.

BETWEEN the Hurricane and Toroweap faults is contained the U′-in-ka-ret block. It is tilted slightly toward the east and is fifteen miles broad. Upon it stands a group of volcanic mountains, the lavas of which have risen through fissures in the block. Between the Toroweap and West Kaibab displacements is the Kan-ab′ block, thirty miles broad. It appears level in the east-west section, but has, in common with all the other blocks of the sketch, a gentle dip to the north. Its cap of Carboniferous limestone is divided in the foreground by the cañon of Kanab creek, and fifty miles away it passes beneath Triassic sandstones. The Kaibab block stands highest of all. The strata, which for fifteen miles run level on its summit, are flexed downward at both margins, on one side to the Kanab block, and on the other to the Marble Cañon block. Its upper surface is the Kaibab Plateau. The Marble Cañon block is thirty miles broad. On the line of the section its highest bed is of Carboniferous age, but a few miles farther north it retains a heavy bed of Trias, which rises 2000 feet higher and constitutes the Paria Plateau.

The features of the region pictured to which I wish especially to call attention, are:

First, that there are no anticlinals and no synclinals, but only monoclinals and faults;

Second, that the throws of the displacements are not all on the same side;

Third, that the visible portion of the earth's crust is divided into great blocks, which have changed their relative and absolute altitudes by thousands of feet, without losing their individuality.

The structure of this region is an unusually pure example of a type that, with various modifications, prevails throughout the Plateau region, and Major Powell has taken a name from the locality and called it the *Kaibab structure.* We cannot study the embryology of mountains by observing the progress of an individual, but it is possible, by the comparison of many individuals in various stages of development, to learn something of the manner of mountain growth, and, studying the subject in this way, the conclusion has been reached that many mountain ranges are built upon the plan of the Kaibab Plateau. The essential feature of the plan is the upward movement *en masse* of a great body of rock between two planes of displacement. A *plateau* is thus produced, from which mountain forms are carved by the ordinary processes of erosion. Evidences of such a plan have been found in nearly all the mountains of the upper basin of the Sevier River, in some of the ranges of the Great Basin, by Major Powell in the Uintah range, and by Mr. Marvine in the Front and Medicine Bow ranges of Colorado. Few of these cases are so simple as that of the Kaibab Plateau. In some the block has been lifted more on one side than on the other, so as to acquire a dip; in other cases there are a number of blocks of different elevation in the same range; in yet other, the blocks are somewhat curved.

I shall not attempt to enumerate the variations of the type, which arise in these several ways. The purpose of the illustration is accomplished, if I have shown that the exceptional exhibition, in the Plateaus, of displacements which are simple and easy of comprehension, has already led to the recognition of a new class of mountain structures, or at least of a class so little known heretofore that it has not found place in the manuals of geology.

When the displacements of the region have all been worked out, it will be possible to construct a model which shall exhibit the structure of at least one hundred and fifty thousand square miles of the earth's crust, showing the form and position of each of the blocks which compose it; and I conceive that such a model, or an equivalent presentation of the same material by some other method, will not be inferior in value to any single contribution that has been made to our knowledge of the results of orographic movements.

Mountain building by eruption.—The studies, which the Plateaus afford in the phenomena of eruption, are scarcely less interesting and important than those of uplift and downthrow; but they have received less attention up to the present time. It happens that a number of extinct eruptive mountains stand near the cañons of the Colorado River. The country about them has suffered and is suffering rapid denudation, and not only are their bases nearly free from detritus, but their flanks are so deeply scored, and their summits are so degraded, that their internal structure is exhibited. Those that are best known have been found to be composed chiefly of sedimentary strata, protected from denudation by the superior durability of the eruptive rocks with which they are associated.

In the U'-in-ka-ret mountains Major Powell found a mass of undisturbed strata, which had been preserved from erosion by a mantle of lava, while the surrounding country was degraded more than a thousand feet. The eruptions were extended through a long period of time, and the successive outflows mantled the flanks of the surviving strata almost as thoroughly as they did the summit, so as to give the appearance, at first glance, of a range made up entirely of volcanic matter.

In the Henry Mountains the strata are not undisturbed, but have been lifted into a number of bubble-shaped domes, one for each individual mountain of the group. Each dome has been fractured at top, and divided by fissures radiating from the center toward the sides, and all the fissures have been filled by molten rock. Moreover the strata have in many places cleaved apart, and lava sheets have been interleaved with them.

Doubtless the intrusion of these dikes and sheets was accompanied by extrusion, but none of the extruded masses appear to have survived the subsequent erosion. The mountains as they stand are simply domes of curved strata. each traversed by a plexus of crystalline dikes.

Similar in structure to the Henry Mountains are Navajo Mountain, Sierra la Sal, and Sierra Abajo. Mount San Francisco, and perhaps Mount Taylor, are related to the Uinkarets. This enumeration includes but a small portion of the volcanic mountains of the district, and to the two types of structure mentioned, several others might be added. But the mountains of the Uinkaret and Henry types are most favorably situated for study, and at the same time diverge most widely in character from those with which geologists are already familiar.

Stratigraphy.—In the stratigraphy of the Plateaus attention has thus far been confined to questions that are chiefly of local importance, but a thorough study of the phenomena which are accessible can hardly fail to throw light on the

principles of sedimentation. In the region of cañons a single bed can be followed, upon one continuous outcrop, for hundreds of miles, and every modification that it undergoes can be traced step by step. Moreover, by reason of the ramifications of cañons, it is frequently possible to trace a bed toward all points of the compass, so as to learn its changes, not merely along a simple line, but throughout an extended area. With such exposures, unconformity cannot escape detection, and the history of a system of sediments can be made out with a completeness that surely cannot be excelled elsewhere.

Part II. Erosion.

It remains to indicate the scope of the material bearing upon the subject of erosion, and with that intent I will discuss certain problems which the region has propounded. The first may be called

The Problem of the Cañons.

The deep gorges which so facilitate the examination of the strata and of their displacements, are themselves of interest as monuments of erosion. To account for their existence and unravel their history is to review the laws of erosion with great wealth of illustration. Results so extreme can have been produced only under conditions equally extreme; and natural laws are often best tested and exemplified by the consideration of their operation under exceptional circumstances. Already the problem of the cañons has been attacked, and I cannot better demonstrate its radical value than by presenting the present aspect of the case. For this purpose it is necessary to give a summary statement of the processes of erosion and of the conditions which determine its rate. The matter is so complex that this cannot be done briefly without the omission of the less important factors, and in undertaking it I shall take the liberty of either disregarding or slighting all considerations which have not an important bearing on the problem in question.

In order to analyse sub-aerial erosion, we must consider it (A) as consisting of parts, and (B) as modified by conditions.

A. All indurated rocks and most earths are bound together by a force of cohesion, which must be overcome before they can be divided and removed. The natural processes by which the division and removal are accomplished make up erosion. They are called disintegration and transportation.

Transportation is chiefly peformed by running water.

Disintegration is naturally divided into two parts. So much of it as is accomplished by running water is called corrasion, and that which is not, is called weathering.

Stated in their natural order, the three general divisions of the process of erosion are (1) *weathering*, (2) *transportation*, and (3) *corrasion*. The rocks of the general surface of the land are disintegrated by *weathering*. The material thus loosened is *transported* by streams to the ocean or other receptacle. In transit it helps to *corrade* from the channels of the streams other material, which joins with it to be transported to the same goal.

(1.) In weathering the chief agents of disintegration are solution, change of temperature, the beating of rain, and vegetation.

The great solvent of rocks is water, but it receives aid from some other substances, of which it becomes the vehicle. These substances are chiefly products of the formation and decomposition of vegetable tissues. Some rocks are disintegrated by their complete solution, but the great majority are divided into grains by the solution of a portion; and fragmental rocks usually lose by solution the cement merely, and are thus reduced to their original, incoherent condition.

The most rigid rocks are cracked by sudden changes of temperature; and the crevices thus begun, are opened by the freezing of the water within them. The coherence of the more porous rocks is impaired and often destroyed by the same expansive force of freezing water.

The beating of the rain overcomes the feeble coherence of earths, and assists solution and frost by detaching the particles which they have partially loosened.

Plants often pry apart rocks by the growth of their roots, but their chief aid to erosion is by increasing the solvent power of percolating water.

(2.) A portion of the water of rains flows over the surface and is quickly gathered into streams. A second portion is absorbed by the earth or rock on which it falls, and after a slow underground circulation reissues in springs. Both transport the products of weathering, the latter carrying dissolved minerals, and the former chiefly undissolved.

Transportation is also performed by currents of air, and by the direct action of gravity; but in the present discussion it will not be necessary to consider these accessory agents.

(3.) In corrasion the agents of disintegration are solution and mechanical wear. Wherever the two are combined, the superior efficiency of the latter is evident; and in all fields of rapid corrasion the part played by solution is so small that it may be disregarded.

The mechanical wear of streams is performed by the aid of hard mineral fragments which are carried along by the current.

The effective force is that of the current; the tools are mud, sand, and bowlders. The most important of them is sand; it is chiefly by the impact and friction of grains of sand that the rocky beds of streams are disintegrated.

Streams of clear water corrade their beds by solution. Muddy streams act partly by solution, but chiefly by attrition.

Streams transport the combined products of corrasion and weathering. A part of the debris is carried in solution, and a part mechanically. The finest of the undissolved detritus is held in suspension; the coarsest is rolled along the bottom; and there is a gradation between the two modes. There is a constant comminution of all the material as it moves, and the work of transportation is thereby accelerated. Bowlders and pebbles, while they wear the stream-bed by pounding and rubbing, are worn still more rapidly themselves. Sand grains are worn and broken by the continued jostling, and their fragments join the suspended mud. Finally the detritus is all more or less dissolved by the water, the finest the most rapidly.

In brief, (1) weathering is performed by solution; by change of temperature, including frost; by rain beating; and by vegetation.

(2) Transportation is performed chiefly by running water.

(3) Corrasion is performed by solution, and by mechanical wear.

Corrasion is distinguished from weathering chiefly by including mechanical wear among its agencies, and the importance of the distinction will be apparent when we come to consider how greatly and peculiarly this agency is affected by modifying conditions.

In the region of cañons, the progress of corrasion has outstripped that of weathering, and to discover what conditions have determined this result, is to solve the problem of the cañons.

B. The chief conditions which affect the rapidity of erosion are (1) declivity, (2) character of rock, and (3) climate.

(1.) In general, *erosion is most rapid where the slope is steepest;* but weathering, transportation and corrasion are affected in different ways and in different degrees.

With increase of slope goes increase in the velocity of running water, and with that goes increase in its power to transport undissolved detritus.

The ability of a stream to corrade by solution is not notably enhanced by great velocity; but its ability to corrade by mechanical wear keeps pace with its ability to transport, or may even increase more rapidly. For not only does the bot-

tom receive more blows in proportion as the quantity of transient detritus increases, but the blows acquire greater force from the accelerated current, and from the greater size of the moving fragments. It is necessary, however, to distinguish the ability to corrade from the rate of corrasion, which will be seen further on to depend largely on other conditions.

Weathering is not directly influenced by slope, but it is reached indirectly through transportation. Solution and frost, the chief agents of rock decay, are both retarded by the excessive accumulation of disintegrated rock. Frost action ceases altogether at a few feet below the surface, and solution gradually decreases as the zone of its activity descends and the circulation on which it depends becomes more sluggish. Hence the rapid removal of the products of weathering stimulates its action, and especially that portion of its action which depends upon frost. If, however, the power of transportation is so great as to remove completely the products of weathering, the work of disintegration is thereby checked; for the soil, which weathering tends to accumulate, is a reservoir to catch rain as it reaches the earth, and store it up for the work of solution and frost, instead of letting it run off at once unused.

In brief, a steep declivity favors transportation and thereby favors corrasion. The rapid, but partial, transportation of weathered rock accelerates weathering; but the complete removal of its products retards weathering.

(2.) Other things being equal, *erosion is most rapid when the eroded rock offers least resistance;* but the rocks which are most favorable to one portion of the process of erosion, do not necessarily stand in the same relation to the others. Disintegration by solution depends in large part on the solubility of the rocks, but it proceeds most rapidly with those fragmental rocks of which the cement is soluble, and of which the texture is open. Disintegration by frost is most rapid in rocks which absorb a large percentage of water and are feebly coherent. Disintegration by mechanical wear is most rapid in soft rocks. Transportation is most favored by those rocks which yield by disintegration the most finely comminuted debris

(3.) The influence of climate upon erosion is less easy to formulate. The direct influences of temperature and rainfall are comparatively simple, but their indirect influence, through vegetation, is complex, and is in part opposed to the direct influence of rainfall.

Temperature affects erosion chiefly by its changes. Where the range of temperature includes the freezing point of water, frost contributes its powerful aid to weathering; and it is only where changes are great and sudden that rocks are cracked by their unequal expansion or contraction.

All the processes of erosion are affected directly by the amount of rainfall, and by its distribution through the year. All are accelerated by its increase and retarded by its diminution. When it is concentrated in one part of the year at the expense of the remainder, transportation and corrasion are accelerated, and weathering is retarded.

Weathering is favored by abundance of moisture. Frost accomplishes most when the rocks are saturated; and solution, when there is the freest subterranean circulation. But when the annual rainfall is concentrated into a limited season, a larger share of the water fails to penetrate, and the gain from temporary flooding does not compensate for the checking of all solution by a long dry season.

Transportation is favored by increasing water supply as greatly as by increasing declivity. When the volume of a stream increases, it becomes at the same time more rapid, and its transporting capacity gains by the increment to velocity as well as by the increment to volume. Hence the increase in power of transportation is more than proportional to the increase of volume.

It is due to this fact chiefly, that the transportation of a stream which is subject to floods is greater than it would be if its total water supply were evenly distributed in time.

The indirect influence of rainfall and temperature, by means of vegetation, has different laws. Vegetation is intimately related to water supply. There is little or none where the annual precipitation is small, and it is profuse where the latter is great and especially where the temperature is at the same time high, In proportion as vegetation is profuse the solvent power of percolating water is increased, and, on the other hand, the ground is sheltered from the mechanical action of rains and rills. The removal of disintegrated rock is greatly impeded by the conservative power of roots and fallen leaves, and a soil is invariably preserved. Transportation is retarded. Weathering by solution is accelerated up to a certain point, but in the end it suffers by the clogging of transportation. The work of frost is nearly stopped as soon as the depth of soil exceeds the limit of frost action. The force of rain-drops is expended on foliage. Moreover a deep soil acts as a distributing reservoir for the water of rains, and tends to equalize the flow of streams.

Hence the general effect of vegetation is to retard erosion; and since the direct effect of great rainfall is the acceleration of erosion, it results that its direct and indirect tendencies are in opposite directions.

In arid regions of which the declivities are sufficient to give thorough drainage, the absence of vegetation is accompanied by

absence of soil. When a shower falls, nearly all the water runs off from the bare rock, and the little that is absorbed is rapidly reduced by evaporation. Solution becomes a slow process for lack of a continuous supply of water, and frost accomplishes its work only when it closely follows the infrequent rain. Thus weathering is retarded, and transportation has its work so concentrated by the quick gathering of showers into floods, as to compensate, in part at least, for the smallness of the total rainfall from which they derive their power.

Hence in regions of small rainfall, surface degradation is usually limited by the slow rate of disintegration; while in regions of great rainfall it is limited by the rate of transportation. There is probably an intermediate condition, with moderate rainfall, in which a rate of disintegration greater than that of an arid climate is balanced by a more rapid transportation than consists with a very moist climate, and in which the rate of degradation attains its maximum.

Having examined the conditions of erosion separately, let us now group them in such combination as will help to an understanding of the cañons.

Over nearly the whole of the earth's surface there is a soil, and wherever this exists we know that the conditions are more favorable to weathering than to transportation. Hence it is true in general that the conditions which limit transportation are those which limit the general degradation of the surface.

To understand the manner in which this limit is reached, it is necessary to look at the process by which the work is accomplished.

Transportation and Comminution.—A stream of water flowing down its bed expends an amount of energy that is measured by the quantity of water and the vertical distance through which it descends. If there were no friction of the water upon its channel the velocity of the current would continually increase; but if, as is the usual case, there is no increase of velocity, then the whole of the energy is consumed in friction. The friction produces inequalities in the motion of the water, and especially induces subsidiary currents more or less oblique to the general onward movement. Some of these subsidiary currents have an upward tendency, and by them is performed the chief work of transportation. They lift small particles from the bottom and hold them in suspension while they move forward with the general current. The finest particles sink most slowly and are carried farthest before they fall. Larger ones are barely lifted, and are dropped at once. Still larger are only half lifted; that is, they are lifted on the side of the current and rolled over,

without quitting the bottom. And finally there is a limit to the power of every current, and the largest fragments of its bed are not moved at all.

There is a definite relation between the velocity of a current and the size of the largest bowlder it will roll. It has been shown by Hopkins that the weight of the bowlder is proportioned to the sixth power of the velocity. It is easily shown also that the weight of a suspended particle is proportioned to the sixth power of the velocity of the upward current that will prevent its sinking. But it must not be inferred that the total load of detritus that a stream will transport bears any such relation to the rapidity of its current. The true inference is, that the velocity determines the limit in coarseness of the detritus that a stream can move by rolling, or can hold in suspension.

Every particle which a stream lifts and sustains is a draft upon its energy, and the measure of the draft is the weight (weighed in water) of the particle, multiplied by the distance it would sink in still water in the time during which it is suspended. If, for the sake of simplicity, we suppose the whole load of a stream to be of uniform particles, then the measure of the energy consumed in their transportation, is their total weight multiplied by the distance one of them would sink in the time occupied in their transportation. Since fine particles sink more slowly than coarse, the same consumption of energy will convey a greater load of fine than of coarse.

Again, the energy of a clear stream is entirely consumed in friction on its bottom; and the friction bears a direct relation to its velocity. But if detritus be added to the water, then a portion of its energy is diverted to the transportation of the load; and this is done at the expense of the friction upon the bottom, and hence at the expense of velocity. As the energy expended in transportation increases, the velocity diminishes. If the detritus be composed of uniform particles, then we may also say that as the load increases, the velocity diminishes. But the diminishing velocity will finally reach a point at which it can barely transport particles of the given size, and when this point is attained, the stream has its maximum load of detritus of the given size. But fine detritus requires less velocity for its transportation than coarse, and will not so soon reduce the current to the limit of its efficiency. A greater per cent of the total energy of the stream can hence be employed by fine detritus than by coarse.

Thus the capacity of a stream for transportation is enhanced by comminution in two ways. Fine detritus, on the one hand, consumes less energy for the transportation of the same weight, and on the other, it can utilize a greater portion of the stream's energy.

It follows, as a corollary, that the velocity of a fully loaded stream depends (*ceteris paribus*) on the comminution of the material of the load. When a stream has its maximum load of fine detritus, its velocity will be less than when carrying its maximum load of coarse detritus; and the greater load corresponds to the less velocity.

It follows also that a stream which is supplied with heterogeneous debris will select the finest. If the finest is sufficient in quantity, the current will be so checked by it, that the coarser cannot be moved. If the finest is not sufficient, the next grade will be taken, and so on.

Transportation and Declivity.—To consider now the relation of declivity to transportation we will assume all other conditions to be constant. Let us suppose that two streams have the same length, the same quantity of water, flow over beds of the same character, and are supplied to their full capacities with detritus of the same kind; but differ in the total amount of fall. Their declivities, or rates of fall, are proportional to their falls. Since the energy of a stream is measured by the product of its volume and its fall, the relative energies of the two streams are proportional to their falls, and hence, proportional to their declivities. The velocities of the two streams, depending as we have seen above, on the character of the detritus which loads them, are the same; and hence the same amount of energy is consumed by each in friction on its bed. And since the energy which each stream expends in transportation is the residual after deducting what it spends in friction from its total energy, it is evident that the stream with the greater declivity will not merely have the greater energy, but will expend a less per cent of it in friction and a greater per cent in transportation.

Hence declivity favors transportation in a degree that is greater than its simple ratio.

[There are two elements of which no account is taken in the preceding discussion, but which need to be mentioned to prevent misapprehension, although they detract in no way from the conclusions.

The first is the addition which the transported detritus makes to the energy of the stream. A stream of water charged with detritus is at once a compound and an unstable fluid. It has been treated merely as an unstable fluid requiring a constant expenditure of energy to maintain its constitution; but looking at it as a compound fluid, it is plain that the energy it developes by its descent, is greater than the energy pertaining to the water alone, in the precise ratio of the mass of the mixture to the mass of the simple water.

The second element is the addition which the detritus makes to the friction of the stream. The coefficient of friction of the compound stream upon its bottom will always be greater than that of the simple stream of water, and hence for the same velocity a greater amount of energy will be consumed.

It may be noted in passing, that the energy which is consumed in the friction of the detritus on the stream bed, accomplishes as part of its work the mechanical corrasion of the bed.]

Transportation and quantity of water.—The friction of a stream upon its bed depends on the character of the bed, on the area of the surface of contact, and on the velocity of the current. When the other elements are constant, the friction varies directly with the area of contact. The area of contact depends on the length and form of the channel, and on the quantity of water. For streams of the same length, and same form of cross-section, but differing in size of cross-section, the area of contact varies directly as the square root of the quantity of water. Hence, *ceteris paribus*, the friction of a stream on its bed, is proportioned to the square root of the quantity of water. But, as stated above, the total energy of a stream is proportioned directly to the quantity of water. And also, the total energy is equal to the energy spent in friction, plus the energy spent in transportation. Whence it follows, that if a stream change its quantity of water without changing its velocity or other accidents, the total energy will change at the same rate as the quantity of water, the energy spent in friction will change at a less rate, and the energy remaining for transportation will change at a greater rate.

It follows, as a corrollary, that the running water which carries the debris of a district, loses power by subdivision toward its sources; and that, unless there is a compensating increment of declivity, the tributaries of a river will fail to supply it with the full load which it is competent to carry.

It is noteworthy also, that the obstruction which vegetation opposes to transportation, is especially effective in that it is applied at the infinitesimal sources of streams, where the force of the running water is least.

A stream which can transport debris of a given size, may be said to be *competent* to such debris. Since the maximum particles which streams are able to move are proportioned to the sixth powers of their velocities, competence depends on velocity. Velocity, in turn, depends on declivity and volume, and (inversely) on load.

In brief, the capacity of a stream for transportation is greater for fine debris than for coarse.

Its capacity for the transportation of a given kind of debris is enlarged in more than simple ratio by increase of declivity; and it is enlarged in more than simple ratio by increase of volume.

The competence of a stream for the transport of debris of a given fineness, is limited by a correspondent velocity.

The *rate* of transportation of debris of a given fineness, may equal the capacity of the transporting stream, or it may be less. When it is less, it is always from the insufficiency of supply. The supply which is furnished by weathering is never available unless the degree of fineness of the debris brings it within the competence of the stream at the point of supply.

The chief point of supply is at the very head of the flowing water. The rain which falls on material that has been disintegrated by weathering, begins, after it has saturated the immediate surface, to flow off. But it forms a very thin sheet; its friction is great; its velocity is small; and it is competent to pick up only particles of exceeding fineness. If the material is heterogeneous, it discriminates and leaves the coarser particles. As the sheet moves on, it becomes deeper, and soon begins to gather itself into rills. As the deepening and concentration of water progresses, either its *capacity* increases and the load of fine particles is augmented, or, if fine particles are not in sufficient force, its *competence* increases, and larger ones are lifted. In either case the load is augmented, and, as rill joins with rill, it steadily grows, until the accumulated water finally passes beyond the zone of disintegrated material.

The particles which the feeble initial currents are not competent to move, have to wait either until they are subdivided by the agencies of weathering, or until the deepening of the channels of the rills so far increases the declivities, that the currents acquire the requisite velocity, or until some fiercer storm floods the ground with a deeper sheet of water.

Thus rate of transportation, as well as capacity for transportation, is favored by fineness of debris, by declivity, and by quantity of water. It is opposed chiefly by vegetation, which holds together that which is loosened by weathering, and shields it from the agent of transportation in the very place where that agent is weakest.

When the current of a stream gradually diminishes in its course—as, for example, in approaching the ocean—the capacity for transportation also diminishes; and so soon as the capacity becomes less than the load, precipitation begins,—the coarser particles being deposited first.

Corrasion.—If a stream has no load of detritus, it corrades only by solution. If it is loaded to its full capacity, it does

not corrade; it is on the verge between corrasion and deposition. Only with a partial load does a stream wear its bottom.

The rapidity of mechanical corrasion depends on the hardness, size, and number of transient fragments, on the hardness of the rock-bed, and on the velocity of the stream. The blows which the moving fragments deal upon the stream-bed are hard, in proportion as the fragments are large and the current is swift. They are most effective when the fragments are hard and the bed-rock is soft. Their number is increased, up to a certain limit, by the increase of the load of the stream; but when the fragments become greatly crowded at the bottom of a stream, their force is partially spent among themselves, and the bed-rock is in the same degree protected. For this reason, and because increase of load causes retardation of current, it is probable that the maximum work of corrasion is performed when the load is far within the transporting capacity.

The element of velocity is of double importance, since it determines, not only the speed, but, to a great extent, the size of the pestles which grind the rocks. The coefficients upon which it in turn depends, namely, declivity and quantity of water, have the same importance in corrasion that they have in transportation.

Let us now direct our attention to the region of the cañons.

The Plateau province lay beneath the ocean up to the close of the Mesozoic age. In early Cenozoic time it was nearly covered by fresh-water lakes, and was not greatly elevated.

In more recent epochs it has been very greatly, but unequally lifted, and the lakes have been drained. The erosion which began with the first lifting of a part above the ocean, and extended its area as the lakes disappeared, has progressed continually to the present time. The average total uplift has been about 12,000 feet; the mean altitude of the present surface is about 7,000 feet; and the difference is the mean amount of degradation. While 5,000 feet have been removed from the general surface, an amount greater by several thousand feet has been corraded by the rivers.

The greater tributaries of the Colorado have their sources in elevated mountains which are well supplied with rain. Their courses through the Plateaus traverse regions characterized by aridity.

On the uplands which border the cañons the supply of water is so small and the declivity is so great that weathering is less favored than transportation. No soil accumulates; vegetation is scant; and, for the lack of these, weathering is reduced to a minimum. The degradation of the surface is limited by the retarded weathering.

In the cañons corrasion is favored by a quantity of water which belongs to the mountain sources of the streams and not to the plateaus which they divide. It is favored by a great declivity of bed, for which it is indebted to the magnitude and recency of the uplift. It is favored by a moderate supply of debris, always sufficient for the work of excavation, but not so great as to consume the entire energy of the current.

The contrast between the degradation of the upland and the cutting of the water ways is strongest where the rocks are best fitted to resist disintegration. The rivers sink their channels into the land in a harmonious and interdependent system, and cannot excavate soft beds more deeply than hard. But the only downward limit to the degradation of the tables is the level of the draining river system; and the varying retardation which it suffers from the resistance of different rocks, is expressed in the varying height of the cañon walls.

A second problem which has arisen in the study of the erosion of the Plateaus may be called

The Problem of Waterfalls.

Where rivers descend a slope that is terraced by the alternation of hard and soft strata, they are apt to leap from the edges of the hard beds in waterfalls. But the Colorado, notwithstanding the structure of its bed presents the most favorable conditions, makes no leap. At the head of Marble Cañon, for instance, the river crosses a great bed of limestone, lying nearly level and underlaid by a great bed of friable sandstone. The limestone resists all erosive agents as strongly as does the Niagara limestone, and the sandstone yields to them as easily as does the Niagara shale. But, instead of plunging from one to the other in a great cataract, the Colorado cuts the two with nearly equal grade of channel. Its average descent in the hard rock is ten feet to the mile, and in the soft, less than five feet.

It is evident that for the production of waterfalls some condition is involved beside that of the constitution of the rock-system which the stream traverses,—some condition that pertains to the constitution of the stream itself. Such a condition is to be found in the relation of corrasion to transportation.

Let us suppose that a stream, endowed with a constant supply of water, is at some point continuously supplied with as great a load as it is capable of carrying. For so great a distance as its velocity remains the same, it will neither corrade nor deposit, but will leave the grade of its bed unchanged. But if in its progress it reaches a place where a less declivity of bed gives a diminished velocity, its capacity for transportation will become less than the load, and part of the load will be depos-

ited. Or if in its progress it reaches a place where a greater declivity of bed gives an increased velocity, the capacity for transportation will become greater than the load, and there will be corrasion of the bed. In this way a stream, which has a supply of debris equal to its capacity, tends to build up the gentler slopes of its bed and cut away the steeper. It tends to establish a single, uniform grade.

Let us now suppose that the stream, after having obliterated all the inequalities of the grade of its bed, loses nearly the whole of its load. Its velocity is at once accelerated and corrasion begins through its whole length. Since the stream has the same declivity, and consequently the same velocity, at all points, its capacity for corrasion is everywhere the same. Its rate of corrasion, however, will depend on the character of its bed. Where the rock is hard, corrasion will be less rapid than where it is soft, and there will result inequalities of grade. But so soon as there is inequality of grade, there is inequality of velocity, and inequality of capacity for corrasion; and where hard rocks have produced declivities, there the capacity for corrasion will be increased. The differentiation will proceed until the capacity for corrasion is everywhere proportioned to the resistance, and no farther,—that is, until there is an equilibrium of action.

In general, we may say that a stream tends to equalize its work in all parts of its course. Its power inheres in its fall, and each foot of fall has the same power. When its work is to corrade and the resistance is unequal, it concentrates its energy where the resistance is great, by crowding many feet of descent into a small space; and diffuses it, where the resistance is small, by using but a small fall in a long distance. When its work is to transport, the resistance is constant, and the fall is evenly distributed by a uniform grade. When its work includes both transportation and corrasion, as is the usual case, its grades are somewhat unequal; and the inequality is greatest when the load is least.

The condition of the Colorado in respect to load, is midway between that of the Niagara and that of the Platte.

The water of the Niagara is nearly devoid of load. The lake of which it is the outlet gathers the detritus of all tributary streams, and only on the occasion of a great storm yields a small portion of it to the Niagara. The work of transportation is at a minimum, and the differentiation of slope dependent on rock structure reaches its maximum in a cataract.

The water of the Platte is supplied with all the load it can move. Major Powell, who has made a careful study of this river, ascribes its peculiar character to the fact that it flows through a region of unconsolidated strata. Its mean declivity

is as great as that of the Colorado, and it would have carved cañons of imposing depth, if only the material of its banks were sufficiently coherent to stand in walls. As it is, the loose sands of the bordering plains are washed and blown into the river, and, its energy being consumed in their transportation, the corrasion of its channel can proceed no faster than the general degradation of the plain. Having little work to perform beside the transportation of its load, it maintains an almost unvaried slope from the foot of the mountains to its mouth.

In that portion of the Colorado which is contained in the Plateau province, the load consumes a share of the energy of the stream and leaves to corrasion the remainder. The slopes of the stream-bed are varied, but not so greatly as those of the Niagara. Where the bed-rock is soft, the declivity is small. Where it is hard, the declivity is relatively great; but in the toughest hornblende rock the mean angle of slope does not exceed three degrees.

The Problem of Inconsequent Drainage.

There is a third problem of erosion now under investigation in the Plateaus that promises results of value and novelty. It was propounded by Major Powell, and is set forth on page 162, *et seq.*, of his "Exploration of the Colorado River." The question to be answered is: What is the relation of the drainage system of the Plateaus to the system of displacements? How far is it *consequent*, how far *antecedent*, how far *super-imposed?*

If a series of sediments, accumulated in an ocean or lake, be subjected to a system of displacements while still under water, and then be converted to dry land by elevation *en masse*, or by the retirement of the water, the rains which fall on it will inaugurate a drainage system perfectly conformable with the system of displacements. Streams will rise along the crest of each anticlinal, will flow from it in the direction of the steepest dip, will unite in the synclinals, and will follow them lengthwise. The axis of each synclinal will be marked by a watercourse; the axis of each anticlinal by a watershed. Such a system is said to be *consequent* on the structure.

If, however, a system of displacements affect a rock series after the series has become continental, it will have already acquired a system of waterways, and, unless the displacements are produced with unusual rapidity, the waters will not be diverted from their accustomed ways. The effect of local elevation will be to stimulate local corrasion, and each river that crosses an uplifted block will, inch by inch as the block rises, deepen its channel and valorously maintain its original course. It will result that the directions of the drainage lines will be

independent of the displacements. Such a drainage system is said to be *antecedent* to the structure.

There is one other case. Suppose a rock series that has been folded and eroded, to be again submerged, and to receive a new accumulation of unconforming sediments. Suppose further, that it once more emerges, and that the new sediments are eroded from its surface. Then the drainage system will have been given by the form of the upper surface of the superior strata, but will be independent of the structure of the inferior series into which it will descend vertically as the erosion progresses. Such a drainage system is said to be *super-imposed* upon the structure of the older series of strata.

A large share of the drainage of the Plateaus is not consequent. How much is super-imposed, and how much antecedent remains to be determined. With the solution of the problem are involved the determination of the antiquity and history of the Green and Colorado Rivers, and the physical history of the great Tertiary lakes; and we may hope that from its discussion will result the establishment of laws, by the aid of which it shall be possible, in other regions, to deduce facts of geological history from an examination of the relation of structure to drainage.

Summary.

The exposure of the rock structure in the Colorado Plateau province is exceptionally thorough. Soil and vegetation obstruct the view less than in other lands, and deep cañons exhibit natural sections in many directions.

The rock structure is simple but not the simplest. The strata have been displaced, but their displacement is so little complex that it can be clearly determined in kind and amount.

In virtue of the simplicity of structure and continuity of exposure, the geologist does not have to put fragmentary data together and grope for the general facts of which they form part, but is able to see all the parts combined in nature in visible wholes. Nothing need be left for doubtful interpretation where everything can be seen; and with the facts of structure conspicuous and beyond question, the mind is left free to search for causes.

The facilities for the study of single, simple displacements, isolated from other phenomena of the same order, are equalled by those for the study of eruptive mountains which are at once simple, isolated, and dissected by erosion.

To the student of stratigraphy are offered continuous exposures of great length.

To the student of erosion are exhibited the most distinguished monuments of its action; and he is given an opportu-

nity to partially isolate certain of the conditions which control the rapidity of erosive action, by viewing their influence where that influence is at a maximum.

No attempt has been made in this brief review to indicate the entire range of the subjects that will interest the geological student of the region. It was proposed rather to call attention to those categories of phenomena which give greatest promise of affording contributions to the body of principles which constitute the science of geology,—as distinguished from the phenomena which will merely enlarge the body of facts upon which its established principles are based. The progress of geological exploration has compassed so small a fraction of the earth's surface that the aspect of the science is modified, in greater or less degree, by the addition of each important mass of facts; and when the contribution from the Plateaus shall have been made, I am confident that its record will find a place in the history of geological progress.

Already the field has yielded to its students results which are new to them, and which are probably new to the world of science. Among them are a type of uplifted mountains, a type of eruptive mountains, a theory of waterfalls, and a classification of drainage systems.

ART. XI.—*Note on the development and homologies of the anterior brain-mass with Sharks and Skates*;* by Prof. BURT G. WILDER.

IN the paper to which I have just referred† are some statements, partly original and partly based upon the authority of others, which, after a comparison of the preparations before you‡ I now believe to require modification.

1. *The structure of the so-called lobe and crus.*—Accepting the common belief (as stated by Owen) that "in sharks a ventricle is continued to each rhinencephalon along its crus from the

* Part of a lecture on the brains of Plagiostomes (one of a course upon the brains of the fish-like Vertebrates, to the special students of Natural History at Cornell University) delivered May 23d, 1876.

† Notes on the American Ganoids, *Amia*, *Lepidosteus*, *Acipenser* and *Polyodon*. I. On the respiratory actions of *Amia* and *Lepidosteus*. II. On the transformations of the tail of *Lepidosteus*. III. On the transformation of the pectoral fins of *Lepidosteus*. IV. On the brains of *Amia*, *Lepidosteus*, *Acipenser* and *Polyodon*. Proc. Am. Assoc. Adv. Sci., 1875, 151–194; 3 plates.

‡ These comprised brains, entire or more or less dissected, of the following forms: *Mustelus lævis*, fœtal, young, and adult; *Acanthias vulgaris*, fœtal, and adult; *Zygæna*, fœtal, and adult; *Carcharias obscurus* (three examples); *Triakis semifasciatus*; *Odontaspis Americanus* (three examples); *Raia* (sp. ?); *Myliobatis bispinosus*; *Torpedo* (sp. ?).

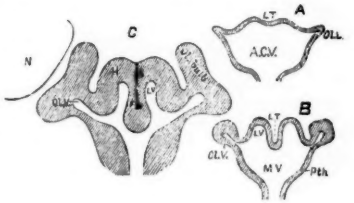
prosencephalon," I was led to conclude that the small hollow bud from the side of the anterior brain-mass (evidently the slightly modified anterior cerebral vesicle) of the fœtal *Mustelus* must elongate and expand at its tip in contact with the olfactory sack so as to form the lobe and crus; page 182. But the young and adult brains since examined show that the ventricle ends as a rounded *cul-de-sac* before reaching the "lobe." The same is the case in *Acanthias* and others with short "crura." In *Myliobatis*, *Carcharias* and others it is even more apparent that the greatly elongated crura are merely bundles of nerve *fibers*, the distal expansion of which forms the so-called lobe. Should there be found ganglionic tissue intermingled with the fibers there would be reason for closer comparison of the mass with the retina of the eye, but not, it seems to me, for regarding it as serially homologous with the optic lobe as a part of the brain. The true olfactory lobe or rhinencephalon seems therefore to embrace only the hollow base of the crus, more or less thickened and more or less distinguishable from the main mass as a conical process. The olfactory bulb, with the more or less elongated crus of many Plagiostomes, seems to be developed independently or in connection with the olfactory sack as are the general nerves. But it is very desirable to trace their formation in forms having long olfactory crura.

2. *The development and position of the hemispheres.*—If the foregoing conclusion be correct, the hemispheres of sharks and skates must be sought for elsewhere than in the thickened and hollow bases of the so-called olfactory crura. The entire anterior mass has been regarded by some as the coalesced hemispheres; and some foundation for this is afforded by the more or less distinct median furrow on its exposed surfaces. But in the adult preparations before you this furrow does not extend over the hinder part of the mass. In several its posterior termination is indicated by a vascular foramen apparently extending vertically through the brain. In the young *Mustelus* and fœtal *Acanthias* the furrow is an actual *fissure* as far back as the foramen above mentioned. The fœtal *Mustelus* presents only a shallow median depression upon the front of the anterior vesicle. Finally the horizontal sections and the dissections show the existence in some adults of the following cavities or ventricles:

A. The y-shaped remnant of the cavity of the anterior vesicle reduced by the great thickening of the walls; the posterior arm opens into the third ventricle behind; the two anterior communicate with the secondary ventricles. B. The olfactory ventricles, continued for a greater or less distance into the olfactory lobes. C. Ventricles, one on each side extending forward and usually inward within the lateral masses separated by the

furrow or fissure. D. In *Odontaspis* and some others there are posterior prolongations of the ventricle upon a higher plane than the anterior horns of the original cavity.

A fuller series of fœtal brains is required for absolute demonstration, but the appearances above described suggest the following conclusion: The hinder part of the mass corresponds to the *prothalami* of Ganoids. The true hemispheres are the lateral masses more or less completely fused on the middle line (as are the olfactory lobes of frogs and toads,) and sometimes developing at the plane of union a bundle of longitudinal commissural fibers. The hemispheres retain their typical condition as anterior protrusions of the anterior vesicle; but they lie mesiad of the olfactory lobes, and, in *Mustelus* at least, seem to be formed after them. It seems probable therefore that the commonly accepted definitions of the hemispheres and the olfactory lobes must be modified with reference to the conditions here indicated: — the latter being developed first and directly from the anterior cerebral vesicle; the former to the inner or mesial side of the olfactory lobes. Their relative positions are thus the reverse of what they are in *Petromyzon*, notwithstanding the other points of resemblance between the Plagiostomes and the Myzonts.



EXPLANATION OF FIGURES.

Figure I.—Diagrams of sections of the large median anterior brain-mass of sharks. A. From embryo *Mustelus* 37 mm. long. Horizontal section (enlarged) of the thin-walled mass which seems to be the slightly modified front and larger portion of the anterior cerebral vesicle. (In Ganoids and Teleosts this mass seems to divide above so as to form the lateral masses called by me *prothalami*). Ol.L. The commencing olfactory lobes. L.T. The center of the *lamina terminalis* or anterior wall of the vesicle. On each side the wall protrudes slightly.

B. From fœtal *Acanthias* 16 cm. long. Horizontal section, enlarged. The walls are thicker; the olfactory lobes are larger, and the lateral protrusions of the lamina terminalis are much more extensive.

C. From an adult *Mustelus*. The olfactory lobe has either expanded into or become connected with a large crescentic bulb into which the ventricle does not extend. The lateral protrusions (H) are closely united by their mesial surfaces at the suture (S). The foramen (F) marks the position of the median line of the lamina terminalis. The cavities are much reduced by the thickening of the walls.

ART. XII.—*New form of Compensating Pendulum;* by J. LAWRENCE SMITH, Louisville, Ky.

IN the construction of this new form of compensating pendulum, I have taken advantage of the very great expansibility of that combination of sulphur and caoutchouc known as vulcanite or ebonite. Its coefficient of expansion is known to approach that of mercury in the ranges of temperature from 0° to 70° C.

The mechanical arrangement adopted is a very simple one. The rod of the pendulum is of round steel, with an adjusting screw at the lower end: a round rod of vulcanite with a hole in the center is passed on to the steel rod, fitting it loosely, and being held in place by the adjusting screw. The bob of the pendulum consists of a heavy mass of brass with a hole through the center large enough to admit the vulcanite over which it passes, and by a properly arranged stop, rests on the end of the vulcanite farthest from the lower end of the pendulum, so that any expansion of the vulcanite elevates the brass bob, thus compensating for the downward expansion of the steel rod and brass bob.

There is a simple mechanical arrangement for adjusting the proper difference between the length of the vulcanite and the other parts of the pendulum.

For a second pendulum to an astronomical clock, I have used the following dimensions: diameter of the steel rod 6 mm.; diameter of vulcanite, 25 mm.; length of same, 165 mm.; diameter of brass bob, 63 mm; length of the same, 156 mm. These dimensions are in no way insisted on as being the best. For a half second pendulum I have used a steel rod 3 mm. in diameter; vulcanite 11 mm. in diameter and 63 mm. long; brass bob 38 mm. in diameter and 57 mm. long.

I have had one of these pendulums attached to an astronomical clock, and after adjustment it has been running four months with very satisfactory results. Should this form of pendulum prove itself constant and correct, it would certainly be a convenient one for transportation, and very much less costly than the ordinary form. And as for the half-second pendulum, in such constant use in mantle clocks, it will be of the greatest service and not add more than 20 cents cost to the commonest form of pendulum that can be used.

As regards the uniformity of the coefficient of expansion of all vulcanites, of course it is not to be supposed that it can be relied upon, but a very simple method is used to ascertain it for any single specimen, or for a number made of the same lot of material.

I have made experiments on several different specimens, and the results vary little from each other. The range of temperature with which the experiments were made was from zero to 43° C., on a bar 25 mm. in diameter, and 304 mm. long, this expanding in length 9–10 mm.; making the entire expansion equal to $\frac{1}{32}$ of the entire length of the rod for a temperature ranging from freezing to boiling point, giving as coefficient for linear expansion for one degree centigrade 0·000079365. This coefficient is seen to be lower than that of mercury; but from the fact that mercury corrects the pendulum by only one-half its expansion, and the vulcanite is made to correct it by its entire expansion, the length of vulcanite required is even less than the column of mercury used in the mercurial pendulum. This instrument is one whose use depends on its accuracy of operation after careful trial for some time.

ART. XIII.—*Aragonite on the surface of a meteoric iron, and a new mineral* (*Daubréelite*) *in the concretions of the interior of the same;* by J. LAWRENCE SMITH, Louisville, Ky.

I. *Incrustation of Aragonite.*

THE remarks in this communication have reference to some of the masses of iron that have been brought from that region of Mexico called the *Bolson de Mapini*, or the Mexican desert, situated in Cohahuila and Chihuahua, two of the northern provinces of Mexico; the desert being four hundred miles from east to west, and five hundred miles from north to south, bordering on the Rio Grande. This region, so prolific in masses of meteoric iron, has been described by Prof. Burckhardt of Bonn as well as by myself.

In 1854 I described three of the masses (this Journal, vol. xxviii, pp. 409); two of these have been brought to the United States, one weighing 125 kilograms and the other 630 kilograms. In 1868, eight others were brought to this country, the heaviest weighing 325 kilograms. These I described in 1869 (this Journ., Nov., 1869); and in 1871 I was enabled to give a description and an analysis of a still larger one weighing about 3500 kilograms, this last one remaining on the western boundary of the desert near El Para.

We have some account of one even larger than the last, located in the very center of the desert. So far as known there have been found in this locality not less than 15,000 kilograms of meteoric matter, an amount exceeding that which has been brought together in cabinets from all other sources.

When I examined the eight masses in 1868, I noticed a white crust on a small part of the surfaces of two of them, but at that time I could not make any critical examination of it. Within the past few months, these irons have come under my control, and therefore I have been enabled to examine the points that had been omitted, the most interesting of which forms the subject of this communication.

On one of these masses of iron, weighing 210 kilograms, there is a small amount of a white incrustation covering about 15 square centimeters of the surface: and on another, weighing 275 kilograms, there is an incrustation, which covered originally over 200 square centimeters of the surface, attached firmly to the iron, and when broken off (as most of it has been by careless handling of the mass), it brings away with it on the under surface a portion of the iron that has become oxidized: its thickness is from one to five millimeters.

It is quite hard, scratching calc spar very readily; the surface of it is irregular and granular. If broken perpendicularly to the surface of the iron and ground down, it will receive a very good polish, showing an irregular and wavy structure on many of the pieces, and parallel to the surface of the iron, with yellow and dark brown streaks like the Gibraltar limerock; it effervesces with acids, and is an incrustation of aragonite.

The following is the composition of the mineral:

Carbonate of lime	93·10
Sesquioxide of iron	1·00
Magnesia	*trace*
Insoluble residue	4·60
Water	1·00

As regards its formation, I am satisfied that the crust has been made on the iron since the fall of the latter. Conceiving this to be the case, I desired to know the nature of the rock and soil where these meteorites were found, and I have been able to gather the following particulars from Dr. Butcher who collected the specimens under examination. This spot is in an alluvial valley or plain between two ranges of high mountains running parallel with each other varying in distance from one to three miles. The mountains at the base are calcareous in formation, and in the hills and plains there are large calcareous deposits. The plain in many places is cut up with deep ravines, and several of the specimens of iron were found among the stones and sand at the bottom of the ravines, and during heavy rains were washed or covered with water. It is however only in wet seasons that the water is found remaining in the ravines and depressions of the valley, and this water is always brackish to the taste, containing a large amount of mineral matter.

Without giving any further details of the nature of this region of Mexico where these meteorites were collected, sufficient has been stated to show the probable source of the calcareous incrustation which I discovered upon two of them.

This incrustation on meteorites has been discovered but twice before, and in both instances by myself. One of them, however, is of so obscure and unsatisfactory a character that I have not given any public notice of it. The other is the case of the Newton County meteorite described by me (this Journal, II, vol. xl, 1865). It is a meteoric stone belonging to the variety classified by M. Daubrée as Syssidères; specimens of it have been furnished by me to the museums of the Garden of Plants, Great Britain and Vienna, with this incrustation in well defined particles of a translucent character adhering firmly to the surface. The entire amount of this meteorite yet known does not exceed 700 grams, although the primitive mass must still exist in a sparsely settled region of Arkansas, and when obtained will no doubt furnish specimens with a larger amount of the calcareous incrustation upon it.

2. *New Meteoric Mineral, Daubréelite.*

Two of the masses of iron above referred to have been cut across, the section made on one of them being over fifteen square decimeters; also several transverse cuts have been made. In all of these sections a number of nodular concretions have been exposed, most of them quite small, and hardly any exceeding a centimeter in diameter. At the first glance all these nodules have the appearance of very finely crystallized troilite; but a little closer inspection reveals the fact that most of these nodules have more or less of a black mineral associated with it. I had never seen anything of the kind before, it being very evident that it was not graphite. As further examination has proved it to be a new and interesting mineral, I have thought proper to designate it after M. Daubrée, who has done so much in the study and elucidation of meteoric minerals.

Daubréelite is a black lustrous mineral, highly crystalline in structure, occurring on the borders of the troilite nodules, and sometimes running across the center of them, as may be seen in one of the specimens, where, in a nodule of troilite, a vein of the mineral traverses the very center of the nodule, which is two millimeters in width and twelve millimeters long. It has a distinct cleavage, but I cannot make out its crystalline form. It is very fragile, and in the attempt to detach it from the iron, it breaks up into small fragments resembling small particles of molybdenite. It is feebly attracted in very fine particles when a strong magnet is brought in contact with it. This may arise from the presence of a minute quantity of troilite which it is

very difficult to get rid of. Pulverized, it furnishes a perfectly black powder, the smallest particle of which gives before the blowpipe a very strong reaction of chromium. Heated very intensely, it loses its brilliant color and becomes a dull black.

The powdered mineral is dissolved completely in nitric acid. The solution is intensely green, and furnishes a strong reaction of sulphuric acid and oxide of chrome. The other strong acids attack it but slightly.

This solubility in nitric acid readily distinguishes it from chrome iron. The quantity of mineral I was enabled to obtain pure, or nearly so, was very small, the reaction of the acids on the mineral being nearly the same as on troilite. I am enabled to separate them only by varying the strength of the acids, and the length of the time they are in contact with the minerals.

Less than one hundred milligrams were obtained of sufficient purity to make out its composition, and this amount furnished me 36·48 per cent of sulphur; the remainder was chrome with nearly ten per cent of iron, and a little carbonaceous matter. This mineral when obtained pure and in sufficient quantity for a thorough analysis (which I hope to make before long), will, I am satisfied, prove to be a protosulphide of chrome. The iron present being mixed with the Daubréelite. The following therefore would express its true composition: Sulphur 37·62, chrome 62·38.

This mineral is an interesting one, and is found in a very strange place, yet from what is revealed to us by the spectroscope with regard to the vapors surrounding the sun, the element chrome must be widely diffused in the matter of the universe.

ART. XIV.—*On some of the changes in the Physical Properties of Steel, produced by Tempering;* by A. S. KIMBALL, Prof. of Physics in the Worcester Institute of Industrial Science.

A FEW interesting, and, to a certain extent, novel results have recently been developed in our laboratory, which I venture to present in their present incomplete form, since the pressure of other duties will postpone, for a few months, further investigations in this direction. Up to the present time the larger number of our experiments have been made upon the behavior of tempered bars under a transverse stress, although a few qualitative trials have been made upon changes in electric conductivity and coefficients of expansion.

I. *The modulus of elasticity decreases as the hardness of the steel increases; in other words the harder the bar, the greater the deflection produced by a given weight.*

Many manuals of practical mechanics give a higher modulus for tempered than for untempered steel. Reuleaux in "Der Constructeur," (page 4,) states that it may be increased 50 per cent by hardening. Coulomb and Tredgold state that hardening has no influence whatever, while Styffe finds that the modulus is diminished. For our first experiment, five pieces of good tool-steel, each 13″ long, were cut from a half-inch square bar. These were carefully annealed, squared, and polished. No. 1 was laid aside and the others were hardened in cold water in the usual manner; No. 2 was "drawn" on a hot plate to a dark blue; No. 3 to a purple; No. 4 to a straw color; No. 5 was left hard. The modulus of elasticity was then determined by measuring the deflection produced by a weight applied at the middle of the bar. The probable error of the experiments did not exceed $\frac{1}{5}$ of one per cent. The experiment was varied in many ways, several qualities of steel and bars of different dimensions were employed with uniform results. In some grades of steel a difference of more than 10 per cent has been found between the modulus of the hardened and that of the annealed bar.

II. *The increase of deflection in a given time is greater, the harder the steel.*

It is well known that the deflection of a bar left under stress will increase for a long time. I am not aware, however, that comparative tests of the rate of increase in steel of different tempers have previously been made.

III. *The immediate set increases with the hardness of the steel.*

In the experiments each bar was of course loaded with the same weight which was allowed to act for the same number of minutes.

IV. *A bar recovers from a temporary set with greater rapidity the harder it is.*

The remarkable fluctuations in the line of the bar observed by Prof. Norton, (this Journal, April, 1876,) became more marked and had a wider range as the hardness of the bar increased. In none of the experiments referred to was a permanent set produced, though in some cases 48 hours had elapsed before the bar recovered its original line. In a few experiments an attempt was made to determine the approximate hardness of the bars by grinding. The results obtained, however, could not be considered very reliable. A more satisfactory method was found in the determination of the temperatures employed in hardening and drawing, by the specific heat of platinum, or by the use of the pyrometer.

I am indebted to Mr. F. C. Blake for the accuracy with which the experiments referred to in this note, have been conducted.

Art. XV.—*A Glass Circle for the measurement of Angles;* by Lewis M. Rutherfurd.

At the summer meeting of the National Academy of Sciences, in the year 1866, I described the micrometer which I had constructed for the measurement of astronomical photographs. It was capable of measuring angles of position, and also distances in directions at right angles to each other. These last measurements were made by aid of screws arranged after the manner of those of an ordinary slide rest: these screws were constructed with great care and I had good reason to be satisfied with the smallness of their errors.

At the Spring meeting of the Academy, for the year 1870, I explained that I had been obliged to give up the idea of using screws on account of the rapid changes in their errors caused by friction and consequent wear, and I then stated that I intended to discard the screw and the compressed slide, and substitute for them a divided glass scale, to be read by a micrometer microscope, and a gravity slide with one V and one flat slide. This intention I carried out during the year, the new form being first used about the month of March, 1871. It has been constantly used since that time, and continues to give great satisfaction. The success of this divided glass scale confirmed me in a determination of long standing to try the experiment of substituting a glass circle for one of metal in some instrument for the measure of angles of precision.

Two years absence in Europe and other occupations conspired to postpone the execution of this plan until the past winter, during which it has been realized with what seems to me the most promising success. I had in my possession a spectrometer by Bruner of Paris—his small model, similar to the one used by Mascart, and figured in his paper on the measures of wave lengths. This instrument has a good steel center and was furnished with a circle divided on silver reading by means of the verniers to 10″. The diameter of the circle is small, not quite seven inches, and the inability to read smaller angles has always been its weak point. I have substituted for this metallic circle, one of glass about ten inches in diameter divided by Mr. Stackpole to ten minutes of arc, and read by two micrometer microscopes magnifying seventy-five times; each revolution of the screws being equivalent to one minute, the drums being divided into sixty parts, read to seconds with easy estimate of fractions—each degree line is numbered so as to be visible in the field of the microscope. I was able to furnish to Mr. Stackpole a well tried diamond which has made lines of the greatest delicacy, being much finer

as seen in the microscopes than the spider lines, by means of which the bisections are made. The advantages of this system are obvious, viz: perfection of surface permitting a line of any desired fineness—facility of illumination permitting the extension of the power of the reading microscopes to several hundred times—smallness of dimensions and consequent cheapness and avoidance of almost all the questions of flexure and local effects of temperature.

I am convinced from the ease with which one second is read on my instrument, with microscopes only $4\frac{3}{4}$ inches long including objectives and eye-pieces, that upon a circle of fifteen inches provided with powerful microscopes, greater precision could be attained in the reading of angles than with the largest metallic circles now in use.

For the purpose of showing the degree of precision attainable, I add two series of bisections of lines on the circle made by myself, and two made by a lady, marked respectively R. and M.

R.	R.	M.	M.
7″·5	1″·8	23″·6	11″·
7 ·4	1 ·3	23 ·6	11 ·2
7 ·7	1 ·9	23 ·3	11 ·8
7 ·4	1 ·8	23 ·8	11 ·
7 ·3	1 ·8	24 ·5	10 ·9
7 ·6	1 ·8	23 ·9	11 ·5
7 ·7	1 ·9	23 ·7	11 ·5
7 ·4	2 ·	24 ·	11 ·5
7 ·6	2 ·3	23 ·9	11 ·
7 ·8	2 ·3	24 ·3	11 ·4
Mean, 7″·54	1″·89	23″·86	11″·28

It will be readily seen that the probable error of any single reading in any one of these series is considerably less than half a second, while the probable error of the mean of any series is a much smaller fraction.

New York, June 1, 1876.

ART. XVI.—*Friedrich Wilhelm August Argelander.**

FRIEDRICH WILHELM AUGUST ARGELANDER was born at Memel, in East Prussia, on the 22d March, 1799. His father, who was of Finnish descent, was a merchant of that town, whilst his mother belonged to a German family. Their circumstances were such as enabled them to give their son a very careful

* This notice is principally an abstract of that by Prof. Schönfeld in *Vierteljahrsschrift der Astronomischen Gesellschaft*, Jahrgang x, part 3, and is here cited from the "Monthly Notices" of the Astronomical Society.

training and education. Political events brought him into very early connection with historic names. After the battle of Jena the Prussian royal family left Berlin, and took up their abode for some time at Memel. The Crown Prince (afterwards King Frederick William IV.) resided at the house of Argelander's father, and formed there a strong and lasting friendship with the future Professor. Scarcely less intimate were his relations with Prince William, the present Emperor of Germany.

In due course young Argelander was sent to the gymnasium at Elbing, and in 1813 to the Collegium Fredericanum at Königsberg, from which, in April, 1817, he proceeded to the University of that town. Although from the first a diligent student, he did not show any special taste for the science in which he was to become so famous until he was attracted thereto by the lectures of Bessel. This led him to request the latter to entrust him with some calculations for the Observatory. The *Fundamenta Astronomiæ* had then been just completed; but Bessel put into his hands the reduction of the observations of 67 stars observed by himself at Königsberg, and not previously observed since Bradley, and also the determination of the latitude of the Observatory from observations of circumpolar stars. The results of these labors were published in the 5th part of the Königsberg Observations, in which he introduced our late Associate to the scientific world as "one of his most distinguished pupils." Other calculations followed, and it was not long before Argelander took part also in the observations; the first of importance being that of the occultation of the *Pleiades* on the 29th of August, 1820. Soon after that, on the 1st of October, he was regularly appointed as Bessel's assistant at the Observatory—the beginning of a career in which he enriched astronomy with results such as could only be obtained by a combination of uncommon genius with industrious zeal.

His first great labor was assisting Bessel in his survey of the heavens by zone observations from 15° south to 45° north declination, in which the whole of the microscope-readings of the circle were made by Argelander, and there is abundant evidence in Bessel's writings how highly he appreciated the care and skill with which this assistance was rendered, as well as that in the subsequent reductions. These zone observations commenced in August, 1821; earlier in that year Argelander was engaged in observations of stars at low altitude to be used in the formation of Bessel's refraction tables, and also in February and March in the observation of the Comet of 1821.

On the 1st of April, 1822, Argelander took his degree as Doctor of Philosophy, after writing a paper, *De Observationibus Astronomicis a Flamsteedio institutis.* Later in the same year

he published his able treatise, *Investigations on the Orbit of the Great Comet of* 1811, which made his name known through Europe. No other comet had been observed so extensively and over so long an interval of time; and after the most skillful and elaborate treatment of the observations, Argelander obtained an orbit of the period of 3,065·6 years (to be reduced in the next period to 2,888 years). His investigations were not without their influence upon Bessel's views on the repulsive force of comets' tails, which were further developed by him afterward in his labors on Halley's Comet and in his controversy with Encke on the resisting medium in space.

On the death of Walbeck, the position of "Observator" at the Observatory at Abo became vacant, and application was made to Bessel to recommend to the authorities at St. Petersburg one of his pupils to supply it. Though exceedingly unwilling to lose him, Bessel named Argelander, and on April 28, 1823, the latter was appointed to the vacant office, and he left Königsberg in the following month, being succeeded there by Rosenberger. His journey to Finland was also his wedding trip, he having married at Königsberg, on the 2d of May, Marie Sophie Charlotte Courtan; and with her he proceeded, through Dorpat (where he renewed his friendship, commenced in November, 1820, with W. Struve) and St. Petersburg, to his new home in the country of his paternal ancestors.

The Observatory at Abo was then newly built and indeed not in all parts quite completed. Its equipments consisted, besides smaller instruments and clocks, of a 2-foot repetition-circle, a Fraunhofer's heliometer, and especially of a very good 8-foot transit instrument by the same artist. A meridian-circle by Ertel was provided in 1825 and was not ready for use until the spring of 1827. Before that time, therefore, the observations principally consisted of comets, and casual phenomena of different kinds. When in possession of the meridian-circle, Argelander undertook a more extended course of observations; and paid special attention in particular to the stars which were known or suspected to have a large proper motion.

In the year 1828 and 1829 Argelander completed Hour XXII of the Berlin Academy Star-charts, which he had undertaken. It is one of the best of the series, and the accompanying catalogue forms one of the earliest examples of the accurate critical treatment of Bessel's and Lalande's zone observations. In the meantime great changes had occurred at Abo. On the 4th of September, 1827 a fire broke out which laid the greatest part of the town in ashes, and destroyed all the buildings, library, &c. of the University. Although the Observatory was protected by its isolated position, and lost nothing but a large

number of its impressions of printed observations, yet it was ultimately resolved to remove it as well as the University to the new capital at Helsingfors. Argelander was named Professor of Astronomy at the newly founded University there, and a new Observatory was ordered to be erected by the architect Engel, who had already built that at Abo. The plan was approved in 1830; but difficulties were found in laying the foundation on account of the nature of the soil. Finland was also visited about this time by the cholera, which travelled over Europe; and Argelander took an opportunity, after leaving Abo, of revisiting his old home in Prussia, and renewing his personal intercourse with Bessel. In August, 1832 he took up his abode at Helsingfors, though the building of the Observatory was not yet finished. Observations commenced there in the following year; and in November, 1834 the meridian-circle was ready for use, the new observatory being also provided with a Munich refracter of 9 ft. focal length and $6\frac{1}{2}$-in. aperture, observations with which commenced in September, 1835.

Argelander devoted himself principally to an extensive series of observations of the brighter circumpolar stars, and to an accurate investigation of his circle, especially of its flexure, by observation of stars and their reflected images. It was whilst at Helsingfors that he printed the Abo observations and catalogue, as well as his well-known treatise on the motion of the solar system deduced from his own observations of 390 stars, with results nearly similar to that formerly obtained by Sir William Herschel.

His stay at Helsingfors was not of long duration. The Prussian Government had resolved in 1836 to establish an astronomical institution at Bonn, on the Rhine. In August of that year the Directorship of the Observatory was offered to Argelander; and early in 1837 he took up his residence in Bonn, and energetically commenced the ordering of the instruments and the preparations for the building of the Observatory. As a temporary *locale* in the meantime for observations, he selected a bastion of an ancient fortress close to the Rhine, where he carried on for some years his astronomical work with such means as he had—latitude determinations, comet observations, &c. He also made excellent use of his involuntary leisure in the formation of his "New Uranometry," or determination of the relative apparent magnitudes of all the stars visible to the naked eye in Central Europe by direct comparison in the sky, as well as in the connected subject of the changes of magnitude of the variable stars. To the latter he continued to give a great deal of attention afterwards, especially in regard to those interesting stars, *Algol* and *S. Cancri*.

Impatient at the slow progress of the Observatory (as he considered it) Argelander had a small temporary building erected, in which he could use (close to his Rhenish bastion) a 5-foot transit instrument by Ertel, of 4 inches aperture. Having provided this with a sector to determine differences of declination, he commenced extending Bessel's zone observations further to the north, from 45° to 80° declination. Thus he made 26,424 observations of very nearly 22,000 stars; which, begun in May, 1841, were essentially completed, with the aid of an assistant, in June, 1843, some gaps being filled up in the subsequent spring.

At last, in the year 1845, the new Observatory was in a position to be used. Its principal instruments were a 3-foot meridian-circle by Pistor, with telescope of 6-foot focal length, and a heliometer by Merz. For some years cometary observations (a large number of which bodies appeared about that time) and observations of the small planets—the long series of discoveries of which had then just commenced—occupied much of the time of the establishment. But in 1849 Argelander began a new series of zone observations of stars, this time going south from Bessel's limit, or from 15° to 31° south declination. Thus, by May, 1852 he had made, in 200 zones, 23,250 observations of more than 17,000 stars. Every precaution was taken by comparison and by observation of known stars to secure the greatest accuracy possible for the results.

But even before the completion of these southern zones, Argelander had formed a plan for a much greater work to extend the knowledge of the starry heavens. Bessel had before conceived the idea of determining the places of all stars down to the ninth magnitude, but had abandoned it for the scheme of the Berlin Academy Star-Charts, which, however, after the lapse of a quarter of a century, were unfinished, and, moreover, they embraced only a limited zone.

Early in 1852, therefore, Argelander resolved to commence that great *Durchmusterung*, or survey of all the stars of the northern hemisphere down to the ninth magnitude, and including a large number somewhat fainter than that, with which his name will be for ever associated. The whole number of stars recorded in these zones, between the north pole and 2° south declination, amounting to 324,198, and this gigantic labor, including the laying down of the charts and publication both of them and of the catalogues occupied Argelander and his assistants until the year 1863. They are too well known to astronomers to make any discussion of them necessary here. In the seventh volume of the *Bonn Observations*, published in 1869, are some interesting investigations into the proper

motions of 250 stars, which Argelander was led into by comparison of observations.

He always kept in view the desirability of obtaining accurate meridional observations of all stars down to the ninth magnitude, whose approximate positions are contained in the *Durchmusterung*. It was necessary, if this could be done, that the labor should be shared by different Observatories, and be prosecuted on a uniform system. Thus would a basis be afforded for a much larger number of accurate determinations and observations of every kind. In the year 1867 Argelander laid his plan before the German Astronomical Society, which was afterwards adopted, with trifling modifications. The Bonn Observatory was to undertake one zone of 10° in breadth of declination; but Argelander, now approaching his seventieth year, entrusted the details of the execution to his assistants, engaging himself in labors of smaller compass, such as investigations of stellar proper motion.

Argelander always took a lively interest in the progress of science generally, and also in the affairs of the University of Bonn, of which he was twice elected Rector. Many of the scientific societies of Europe and America made him one of their corresponding or honorary members, and he was chosen an Associate of our own on the 14th of January, 1831, being also our medallist in the year 1863.

Until the summer of 1874 he had always enjoyed excellent health; but in August of that year he was attacked by a fever of the typhus kind, which visited the neighborhood about that time. In the autumn he rallied, and was able to resume some of his labors. But the appearance of recovery was delusive; his strength failed more and more, and, retaining his interest in science almost to the last, a tranquil death early in the morning of February 17, 1875, terminated a life which had been so useful to astronomy. His wife (with whom he had been affectionately united for nearly fifty-two years), two sons, and one daughter, married to Professor Krüger, survive him.

W. T. L.

ART. XVII.—*On Dinitroparadibrombenzols and their Derivatives;* by PETER TOWNSEND AUSTEN. First Paper.

Two kilograms of pure crystallized solid (para) dibrombenzol were divided into portions of 250 grams, and each portion added to a mixture of 800 grams of fuming nitric acid and an equal volume of concentrated sulphuric acid, and then heated on a sand bath, when a violent action set in, during which it was found advisable to remove the burners. A red-

dish yellow oil settled in the bottom of the flask. After boiling three hours the mixture was allowed to cool, and then poured in a thin stream into a large excess of cold water. The oil sank to the bottom and gradually solidified, an operation which may be greatly accelerated by vigorous stirring with a glass rod. The nitrired product from 500 grams of the dibrombenzol after the washing out the acid with water, was dissolved in about a kilogram of glacial acetic acid, filtered, and allowed to stand about seventy hours. A copious separation of the first (α) dinitroparadibrombenzol, containing a considerable amount of the second (β) isomere and but a small amount of the third (γ), took place. By repeated crystallization, first from carbon disulphide and then from glacial acetic acid, it was obtained perfectly pure. The acetic acid filtrate from the first separation contained the β- and γ-isomeres and some of the α. The solution was treated with a large excess of water, and the substances in solution were thus precipitated in the form of a yellow oil, which was then separated from the water by means of a stop-cock-funnel, heated on a water-bath until it was entirely dry, dissolved in about $1\frac{1}{4}$ kilos. of carbon disulphide, and allowed to stand By standing, a small separation of impure α-isomere generally occurs. The carbon disulphide was then distilled off in portions of 200 c. c., and the respective crystallizations, which consisted of the β-isomere containing a good deal of the α-isomere and traces of the γ, collected. When no more separated the thick oil was heated on a water-bath until the carbon disulphide was entirely volatilized, after which it was exposed to a temperature of 5° for three days, when it became solid. The mass was carefully rubbed in a mortar with ether, at the same temperature, and this ethereal extract (consisting of much γ and little β) separated by a filter-pump. The ether was then evaporated, the oil again exposed to the same temperature, and the operation repeated until the substance dissolved in the ether without leaving a residue. The oil was then exposed to a temperature of about $-8°$ to $-10°$, for nearly two weeks, during which small amounts of the β-isomeres crystallized out and were separated by filtering the oil directly with the filter-pump. Finally no more separated from the oil, which then appeared to contain only an exceedingly small amount of the β-isomere.

Alphadinitroparadibrombenzol.

The alphadinitroparadibrombenzol containing traces of the β-isomere crystallizes from glacial acetic acid in beautiful striated transparent needles, often attaining a length of 25 cm. and a diameter of 3 mm. When perfectly pure, however, it crystallizes from the same solvent, in short, compact, white,

glittering needles, or small prisms. From carbon disulphide it separates in the form of small, hard, white crystals. The compound is insoluble in water, easily soluble in boiling absolute alcohol and glacial acetic acid, as well as in benzol, and acetic ether. It is slightly volatile in steam. Fuses at 159° to a transparent slightly yellow liquid.

0·3034 grm. substance gave 0·0190 H^2O and 0·2452 CO^2.
0·1749 grm. substance after the method of Carius gave 0·1998 AgBr and 0·0027 Ag.

Calculated for $C^6H^2(NO^2)^2Br^2$.	Found.	
	I.	II.
C = 22·08	22·04	....
H = 0·61	0·69	....
Br = 49·08	...	49·74

Nitroparadibromaniline.

In a preliminary notice* I mentioned that α dinitroparadibrombenzol by treatment with ammonia formed a dinitrobromaniline, which under the influence of amylnitrite gave a dinitromonobrombenzol. By repetition of the experiments, however, with much larger amounts and perfectly pure substances, I find that the reaction is different.

By treating the α-dinitroparadibrombenzol with strong alcoholic ammonia the crystals take on a light straw yellow color. By heating in a closed tube at 100° for three hours the reaction is completed. The red solution obtained was precipitated with water and the resulting yellow precipitate crystallized from dilute alcohol. The filtrate from the precipitate produced by water gave no trace of bromine with silver nitrate, but starch and potassium iodide proved the presence of a considerable amount of nitrous acid.

By repeated crystallizations from alcohol the substance was obtained pure. It forms orange, yellow, and red needles, which fuse at 75°, and are quite volatile with steam. It is very soluble in most solvents, with the exception of water in which it dissolves with difficulty.

0·28 grm. substance, third crystallization, gave 0·0426 H^2O and 0·2536 CO^2.

0·2092 grm. substance, fifth crystallization, gave, after the method of Carius, 0·2644 grm. AgBr and 0·0008 Ag.

Calculated for $C^6H^3Br^2(NO^2).NH^2$.	Found.	
	I.	II.
C = 24·32	24·69	....
H = 1·01	1·65	....
Br = 54·05	....	54·06

* Ber. d. d. chem. Ges., viii, 1183.

Amyl nitrite acts at ordinary temperatures on the nitroparadibromaniline and forms, not as I formerly supposed, a dinitromonobrombenzol, but the ordinary mononitroparadibrombenzol. All the properties of the nitrodibrombenzol (fusing point 84°) obtained in this manner agreed perfectly with those of the well-known mononitroparadibrombenzol.

This, as far as I know, is the first case in which the nitroxyl of a nitro-haloid-benzol is substituted by the amido-group in preference to the haloid atom. In the first series there is among others the well-known formation of guanidine from nitrochloroform by action of ammonia, effected by Hofmann.*

It seemed extremely improbable that aniline could act in a satisfactory manner on the alphadinitroparadibrombenzol, since the disengaged nitro-group would, without doubt, exert a decomposing influence on the aniline itself as well as on the new compound formed. The dinitrodibrombenzol was treated with an excess of aniline, and the mixture boiled. A strong reaction, attended with a characteristic deep red color, occurred. Chlorhydric acid precipitated an oil, and, by stirring, brown flocks were obtained. The product was soluble in alcohol with a deep red color, but separated from the solution as a slimy mass from which no product susceptible of analysis could be obtained.

By the action of natriumhydrate solution on the alphadinitroparadibrombenzol, I have obtained a substance forming red salts, which I take to be a nitrobromphenol, and concerning which I shall, at the earliest opportunity, give full particulars.

Royal Laboratory of Berlin, April 16th, 1876.

ART. XVIII.—*On a New Formation of Dinitroaniline, and some Reactions of Dinitrobrombenzol;* by PETER TOWNSEND AUSTEN.

ENGAGED in an extensive research concerning the stability of the bromine atom in dinitromonobrombenzol, I was led to treat that compound with potassium cyanate in the hope of obtaining a dinitrophenylcyanic ester, according to the reaction,

$$C^6H^3(NO^2)^2Br + KNCO = C^6H^3(NO^2)^2NCO + KBr.$$

Dinitrobrombenzol was mixed with about one and a half times its volume of potassium cyanate, and the mixture heated to 100° in a closed tube with very dilute alcohol for eight hours; on cooling, the tube became filled with a mass of bright yellow leaflets, and on opening gave off carbonic acid. The

* Ann. Chem. Pharm., cxxxix, 107.

substance, after crystallization from boiling water, fused at 175°–176°, and on analysis* proved to be the ordinary dinitroaniline.

The reaction by which dinitroaniline is formed admits of various explanations. Wöhler has shown that potassium cyanate by repeated distillation with water, splits according to the formula—

$$2KNCO+4H^2O=CO^3(NH^4)^2+CO^3K^2.$$

Hence we may suppose the formation of the dinitroaniline to be due simply to the action of the dinitrobrombenzol on the ammonium carbonate,

$$CO^3(NH^4)^2+2C^6H^3(NO^2)^2Br=2C^6H^3(NO^2)^2NH^2+CO^2+H^2O+2HBr.$$

The bromhydric acid thus formed acts on the potassium carbonate, so that the whole reaction is—

$$2CONK+2C^6H^3(NO^2)^2Br+4H^2O=2C^6H^3(NO^2)^2NH^2+2CO^2+2KBr+2H^2O.$$

We can, however, suppose the action to take place directly without admitting the previous formation of ammonium carbonate—

$$C^6H^3(NO^2)^2Br+KNCO+H^2O=C^6H^3(NO^2)^2NH^2+KBr+CO^2.$$

Nor is there anything very improbable in the supposition that ammonium carbonate is not formed previously, as there are so many cases in which a substance withdraws from another elements not previously directly united with each other, but with which it can form a compound (predisposing affinity).

It is, however, also not impossible that the formation of the dinitroaniline may depend upon the production and subsequent decomposition of a dinitrophenylcyanic ester according to the reaction discovered by Wurtz,

$$C^6H^3(NO^2)^2N\left|\begin{matrix}\overline{CO}\\ H^2\end{matrix}\right|\overline{O}$$

but this appears to me doubtful, since the dinitrobrombenzol is not freely soluble in the very dilute alcohol used. Hence the potassium cyanate is exposed principally to the action of the water, and much less to the action of the dinitrobrombenzol; therefore, although a partial formation of the ester might take place, the chief part of the potassium cyanate would be decomposed at the same time by the action of the water, so that if the ester were formed, it could only be in small quantities.

* Calculated. Found.

C = 39·34	39·35
H = 2·72	3·01

Mononitrobrombenzol and Potassium Cyanate.

The substances, heated in a sealed tube to 100° with dilute alcohol for eight hours, gave no mononitroaniline, as was to be expected, since mononitrobrombenzol is not acted on by ammonia itself under 160°. The cyanate, however, was completely converted into the corresponding carbonates.

Trinitrochlorbenzol and Potassium Cyanate.

By boiling a concentrated solution of potassium cyanate with trinitrochlorbenzol, I obtained, with strong evolution of ammonia, a red oil which solidified on cooling, and contained considerable unchanged trinitrochlorbenzol. The filtrate contained chlorine (showing that a reaction had taken place), and some picric acid, while chlorhydric acid precipitated a green powder. I have not as yet had time to examine either of these substances farther than to establish the absence of trinitroaniline. By heating for five hours at 100° no picramide was obtained.

Dinitrobrombenzol and Water.

Gottlieb* has stated that trinitrochlorbenzol was decomposed in the cold by water. It was afterwards found by Clemm† that this was not the case, trinitrochlorbenzol not being acted on by water even when boiling. Later, however, Engelhardt and Latschinoff‡ found it was acted on by boiling water.

With dinitrobrombenzol I found no action on boiling with water. The substance was then heated with water in closed tubes successively at 100°, 150°, and 200°, for eight hours, in all these tubes there was no pressure or formation of bromhydric acid. At 220° a minute trace of bromhydric acid had formed, and the liquid was perceptibly reddened on addition of sodium hydrate solution. After heating at this temperature the substance remained liquid for several days, although when it had solidified, it was found to have lost none of its characteristic properties.

Dinitrobrombenzol and Potassium Nitrite.

It appeared not impossible from the ease with which the bromine atom in dinitrobrombenzol can be substituted (although this is chiefly the case in substitution by a positive radical), that by action of potassium nitrite a trinitrobenzol might be formed. The substances were heated in a closed tube six hours with dilute alcohol at 100°. The tube on cooling contained massive red needles of potassium dinitrophenylate. Much aldehyde had also formed. The reaction had probably been—

* Ann. Chem. Pharm., xcii, 326. † Journ. fr. pr. Chem., [2], i, 145.
‡ Zeit. Chem., 1870, 235.

$$C^6H^3(NO^2)^2Br+2KNO^2=C^6H^3(NO^2)^2OK+KBr+(N^2O^3\ ?)$$

The resulting nitrogen oxide, or oxides, had acted on the alcohol and produced aldehyde. Sealed under the same conditions with 99 per cent alcohol, there was but an exceedingly slight reaction, only traces of the phenol having been formed, which doubtless owed their origin to the small amount of water present. The same results were obtained with sodium nitrite. I shall describe the application of this method of phenol formation to other compounds at another opportunity.

Dinitrobrombenzol, Benzol, and Zinc.

Since benzylchloride treated with benzol and zinc dust gives a benzylbenzol, it seemed not improbable that dinitrobrombenzol might give a dinitrodiphenyl, owing to the weakened attraction of the bromine atom from the presence of the nitro-group, although in this case the bromine atom is attached directly to the benzol skeleton, and not indirectly, as in the benzylchloride.

Dinitrobrombenzol, benzol, and zinc dust were heated twelve hours in a closed tube at 100°, and then again at 160°. In both cases there was no action. Toluol instead of benzol also remained unchanged. Perhaps nitro toluol, in which the hydrogen atom of the methyl-group may be weakened by the introduction of the nitro-group in the benzol kernel, may give better results.

Dinitrobrombenzol and Sodium Acetate.

Wishing to ascertain if a dinitrophenyl acetic ester could be obtained according the reaction

$$C^6H^3(NO^2)^2Br,+CH^3COONa=CH^3COOC^6H^3(NO^2)^2+NaBr,$$

I heated the substances with alcohol for six hours in a closed tube at 100°. There was no pressure on opening the tube, but a strong smell of acetic ether. The tube contained orange-red crystals of sodium dinitrophenylate, and in the solution there was considerable sodium bromide. The reaction had probably gone.

$$\text{I.}\quad \begin{matrix} C^6H^3(NO^2)^2\overline{|BrNa|}O.OC.CH^3 \\ C^2H^5\overline{|OH|} \end{matrix} = \begin{cases} C^6H^3(NO^2)^2OH \\ CH^3COOC^2H^5 \\ NaBr. \end{cases}$$

$$\text{II.}\quad \begin{matrix} C^6H^3(NO^2)^2O\overline{|H} \\ CN^3.COO\overline{Na|} \end{matrix} = \begin{cases} C^6H^3(NO^2)^2ONa \\ CH^3.COOH. \end{cases}$$

$$\text{III.}\quad \begin{matrix} CH^3.COO\overline{|H} \\ C^2H^5\overline{|OH|} \end{matrix} = \begin{cases} CH^3.COOC^2H^5 \\ H^2O. \end{cases}$$

So that the whole reaction would be—

$$C^6H^3(NO^2)^2Br + 2CH^3.COONa + 2C^2H^5OH = C^6H^3(NO^2)^2ONa + NaBr + H^2O + 2CH^3COOC^2H^5.$$

The next time, to avoid the formation of acetic ether, the substances were heated with glacial acetic acid at 160°. The whole product was sodium dinitrophenylate. Hence probably,

$$\left.\begin{array}{|l} C^6H^3(NO^2)^2|Br. \\ \overline{CH^3.COO}|Na \\ \overline{CH^3.CO}|\overline{ONa} \end{array}\right| = \left\{\begin{array}{l} C^6H^3(NO^2)^2ONa \\ (C^2H^3O)^2O \\ NaBr, \end{array}\right.$$

although at the time I neglected to prove the formation of the acetic anhydride. The substances heated, under the same conditions with acetic anhydride, remained entirely unchanged.

We see hence that although the stability of the bromine atom is greatly weakened by the introduction of nitro-groups, this weakening is to a great extent only in relation to positive radicals. Thus dinitrobrombenzol reacts easily with ammonia, but with potassium nitrite or sodium acetate there is no analogous reaction. By inversion it naturally follows that in aniline the amido-group must be rendered much more stable by the introduction of nitro-groups. This is shown to be so by the fact that while aniline is most violently acted on by amylnitrite, trinitroaniline remains, under the same treatment, utterly unaffected.

ART. XIX.—*On Southern New England during the melting of the Great Glacier;** by JAMES D. DANA.

APPENDIX: *On the discharge of the flooded Mill River into the Quinnipiac, and the effects as registered in the drift deposits of the New Haven plain.*

IN my memoir on "Southern New England during the melting of the great Glacier," I reached the conclusion† that, during the Champlain period, or that which opened with the melting of the ice, the southern coast of New England, along Long Island Sound, was submerged below its present level not more than fifteen feet, and perhaps less than ten. It was announced,‡ as a consequence of this fact, that the high terraces of stratified drift about the heads of the estuaries and along the river valleys could not have been made by salt water, and must have been due to the freshwaters of the enormously

* The former parts of this memoir are contained in this Journal, III, x, 168, 280, 353, 409, 497, and xi, 178.

† Ibid., x, 434.

‡ Ibid., x, 435.

flooded streams; and that all the drift-deposits of the New Haven region, now thirty to fifty feet above mean tide, were included in the freshwater formations—the saltwater beds being confined to the coast.

The New Haven deposits had been described* as having, to a great extent, a cross-laminated structure, with the oblique lamination dipping for the most part seaward; and hence it was evident—contrary to what I had once supposed—that this dip corresponded in direction with the flow, both being seaward. My former conclusion on this point was based on the view that the New Haven estuary beds were marine in origin; and this appeared to be sustained by the fact† that in the stratified drift beds at the mouth of the Quinnipiac Valley (or where the valley expands into the New Haven plain, west of C on the map, p. 415 of vol. x), the *upper* stratum, twenty feet thick, had the cross-lamination dipping landward, and the *underlying* stratum seaward; for the change of current indicated by this local change of dip seemed to be accounted for by supposing the lower stratum to have been made by the incoming tide, and the upper by the outflowing stream when the flood was at its height. I closed my memoir by rejecting this explanation of the change of current, but without offering any other in its place.

My object at this time is to give another explanation; and to show that while the Quinnipiac waters deposited the lower stratum, the upper was formed by a discharge of Mill River into the Quinnipiac over the place where the unlike strata occur.

As has been explained (and is illustrated on the map, page 415 of volume x), Mill River and the Quinnipiac are parallel streams, joining their waters at the head of New Haven Bay. For the last nine miles of their courses they are less than three miles apart; and the low dividing ridge (Quinnipiac Ridge of the map) terminates near New Haven in the short trap and sandstone ridge called East Rock (E, on the map). Below this termination no barrier intervenes excepting a plain of drift deposits, and here is the place where the upper stratum of twenty feet has the reversed cross-bedding. Now if it can be shown that Mill River was throughout its course a violent cataract, flowing at a level far above that of the Quinnipiac, while the Quinnipiac for the last six miles had almost no descent, and was in this part more like a lake or basin than a river, it will be plain that Mill River, on clearing the south extremity of the East Rock ridge, would have rushed around the point, toward the Quinnipiac.

The facts sustaining this view have already been stated in

* Ibid., x, 191. † Ibid., x, 173.

my former papers.* At North Haven, or six miles north of New Haven, the Quinnipiac River is now on a level with the ocean, while Mill River in the same latitude is sixty feet above it. The valley-terrace of stratified drift is, in each valley, about forty-five feet in height above the stream. Consequently, in the Champlain period the descent, from that point to Long Island Sound, of Mill River was 105 feet, and of the Quinnipiac, only forty-five feet. Moreover, the Quinnipiac terrace has nearly the same height at North Haven and five miles south; so that the waters over this broad area during the Champlain flood were nearly those of a great basin. But, abreast of this long Quinnipiac basin, the Mill River torrent was dashing on with a pitch of ten feet a mile. And it continued this rapid plunging course along its shallow valley until it had passed East Rock, where the valley terrace is seven feet higher than that of the Quinnipiac adjoining. It is therefore manifest that, on reaching the southern extremity of the ridge separating the two valleys, it would have made a quick turn around the promontory and plunged into the Quinnipiac basin; and this would have carried it northeastward directly over the place where the evidences of reversed currents occur in the drift deposits. This place of discharge would not have taken off all the Mill River waters, or the larger part; for the water level there, when the flood was at its height, was still thirty to thirty-five feet above the sea-level—height enough to have kept the tumultuous waters mainly on a seaward course.

We hence learn from the drift deposits at this place of junction of the two streams, southeast of East Rock, (a mile north of the present head of New Haven Bay and six miles from its eastern cape), the following facts:

1. Until the waters of the flooded streams had reached, at the place mentioned, a height of fifteen feet above the then-existing sea-level, neither stream overbalanced the other; for the deposits of the lower stratum within the range of the Quinnipiac valley show, by their structure, that they were made by the flow of Quinnipiac waters. The pitch of the waters to the Sound was then but two or two and a half feet a mile.

2. Until the same water-level was reached, the flow—though rapid and plunging, as proved by the flow-and-plunge structure of the beds—was quiet compared with what followed; for this lower stratum consists mainly of sand and fine pebbles.

3. The increase in the flood on passing that level was sudden, as if the dissolution of the glacier had then received greatly accelerated progress. For the transition in the bedding, and in the color of the sands, is abrupt, with no fine layer between to indicate an epoch of repose; and, moreover, the *upper* stratum is

* Ibid., x, 413.

very much the coarsest; along Mill River valley, it is to a great extent, in contrast with the stratum it overlies, a cobble stone deposit, and this evidence of hurrying waters continues along its course through the New Haven plain for a mile and a half to the Bay.* Further, the height of the deposits where the stones are coarsest is ten feet below the normal height, because in the dashing flood, the finer material was drifted off.

4. The flow from Mill River into the Quinnipiac basin diminished in velocity as the waters spread in that direction. For, while the upper stratum adjoining Mill River on the east is a mass of coarse pebbles, too stony to show any cross-bedding, going farther eastward, toward the Quinnipiac, the stony character diminishes, and finally, in the course of three-fourths of a mile, the beds consist largely of sand.

5. The great plain of stratified drift, southeast of East Rock, forty to forty-three feet in height above the sea-level, which bounds the Quinnipiac salt meadows on the south and pushes the river against the eastern hills, was made largely of sands contributed by the Mill River torrent.

6. The Quinnipiac waters added little to the height of this drift-deposit plain or terrace: for the upper stratum bears evidence of Mill River action nearly or quite to its top. There are over the top some areas of whitish sand, one to three or four feet thick; and a bank of such sand, finely and evenly bedded, lies, unconformably against the slope of stratified drift facing the Quinnipiac basin;† and these may be formations from the Quinnipiac waters after the Mill River floods had subsided.

7. Mill River—now not over fifteen miles in length—is an example of a little stream that was a great river during the Glacial flood. It owes this partly to its having been one of the water-courses that aided, as I have pointed out,‡ in discharging the flooded Connecticut—the overflow at Northampton and Westfield giving a vast supply of waters to the Farmington Valley, enough to fill the wide valley over a hundred feet in depth, and forcing them to find a discharge into Long Island Sound by the Quinnipiac and Mill Rivers. It was probably through this supply of waters from the Connecticut that the floods of Mill River were prolonged until the drift deposits of the New Haven plain had reached their extreme height.

* Ibid., x, 175.

† Ibid., x, 179, 180, where a figure is given. The origin of these beds is otherwise explained at that place, the error that the estuary beds were marine, coloring much of the reasoning in that first paper on "Southern New England."

‡ Ibid., x, 506.

ART. XX.—*The Greenstones of New Hampshire and their organic remains;* by GEO. W. HAWES. With plate V.

THE occurrence in Eastern North America of rocks pertaining to what is appropriately styled the "greenstone" series has been noticed by different observers. In a report upon the geology of the Connecticut Valley, Professor Edward Hitchcock distinguished these from all the other rocks, by the name of "chloritic and talcose schists."* Dr. T. Sterry Hunt, in the Geology of Canada, has given analyses and descriptions of greenstones, and has discussed their mode of formation. Professor C. H. Hitchcock has noticed these rocks in New Hampshire, and has carefully studied their extent and distribution.† The "chloritic formation" near New Haven, which was noticed at length by Percival, has been recently determined by Professor J. D. Dana to consist of greenstones, and its relationship to the surrounding formations has been by him pointed out.‡ In the present article it is proposed to describe some of the more important members of this group occurring in New Hampshire, and, from the evidence afforded by chemical and microscopic study, to attempt to show their origin and mode of formation. These studies have been prosecuted under the direction of the Geological Survey of New Hampshire, at the head of which is Professor C. H. Hitchcock, and with his aid it is proposed to prepare a treatise, as complete as possible, upon the rocks of the State, which will form a part of the third volume of his report.

These greenstones, as described by Professor Hitchcock, cover a large area in the northern part of the State, and extend southward over a long irregular strip of territory which follows the course of the Connecticut Valley. They are referred by him to the Huronian age. The rocks of the whole formation are very generally green, and there is a remarkable constancy in their mineral and chemical composition, owing doubtless to the constancy of the conditions under which the beds were originally accumulated. There is sufficient diversity in these rocks, both in physical and chemical properties, to allow the best of evidence to be obtained in the field, showing that they are all metamorphosed sedimentary accumulations, instead of igneous in origin, as too generally claimed for rocks of this class. They are interstratified with one another in various ways, and are far from appearing as a result of violent eruptions,

* This Journal, I, vi, 26.

† This Journal, III, vii, 468 and 557, also vol. i, Geology of New Hampshire, p. 532.

‡ This Journal, III, xi, 119.

they were accumulated in quiet waters and consolidated under very gentle influences.

As in the vicinity of New Haven—where the rocks have been shown to be of undoubted metamorphic origin—many kinds are found which so closely resemble true trap rocks, that it is well nigh impossible to distinguish them in hand specimens; and, as will be seen beyond—there are cases where even the most careful microscopic study is inconclusive. Although only extended observations made in the field can decide whether the rocks are truly stratified or intrusive, yet it is believed that some characters are given in the descriptions beyond which will be of service in their classification.

The old name "greenstone" is a good general term to apply to the whole group, because the prevailing color of the rocks is green; indeed it is so common that the formation has always been colored green upon the geological maps; and the term "greenstone" has now become so wide in its meaning that it may well embrace all the rocks of the formation. It is intended to include under the term, all basic metamorphic rocks whose prominent coloring ingredient is either hornblende, pyroxene or chlorite. There are green acidic rocks in the formation, but they do not sufficiently resemble the rest to need to come under a common term. The true greenstones are all so much alike in physical appearance, that if the term is restricted as proposed it will be found of much convenience in use.

In this formation there are many varieties of all the rocks spoken of in this article. It is proposed here to describe these variations in but general terms, but in the third volume of the Geology of New Hampshire, the rocks will be more minutely described, additional figures will be given, together with the results of the study of the other rocks found with these, but which are not greenstones if we restrict that term as proposed.

1. *Metamorphic Dioryte.*—The most prominent member of this group of greenstones is metamorphic dioryte, or *metadioryte*, and it includes both oligoclase-dioryte and labradorite-dioryte; varieties which in the region cannot be distinguished without a chemical analysis. This rock is very variable in its texture in different localities, sometimes being so coarse as to enable one to separate the crystals mechanically, and observe the cleavages of the minerals; sometimes being very compact, and well nigh impossible to distinguish from doleryte. The hornblende gives a dark color to the rock, and by this property it is easily distinguished from the light green chloritic rocks. The feldspar is not easy to determine; but an examination of its optical properties shows it to be triclinic. Whether it be oligoclase or labradorite is not a matter of great importance, since a very slight variation in the composition of the sediments would produce a change in the species.

The microscope furnishes as conclusive proof as the stratigraphy that these diorytes are metamorphic. Often in these basic rocks free quartz is associated with feldspars low in silica: and in Stewartstown there is a dioryte in which carbonate of lime is associated with a triclinic feldspar, and also free quartz. Such circumstances as these are easily understood, if these rocks were consolidated under very gentle metamorphic influences, but would not be expected in a rock which had been once in a condition of igneous fusion except as a result of alteration. It seems as if the mass had been under such conditions of heat and pressure as to give action to chemical affinities, but only within a very narrow range; so that crystals of different minerals might be formed from *fine* mud, while a larger grain of sand would be left unaffected. The conditions of metamorphism were such that they gave full scope to chemical affinity, only where the original deposits were impalpable in texture.

These diorytes vary much in their mineral composition. At Littleton some are very feldspathic, with large crystals of labradorite, making a porphyritic dioryte. At North Lisbon some specimens are very hornblendic, and large crystals of hornblende are developed in the finer ground-mass. At Lancaster they are very micaceous, and there are everywhere coarse-grained and fine-grained varieties. Fig. 1, plate IV. is intended to illustrate the appearance of the minerals of these diorytes under the microscope with ordinary transmitted light. It is drawn from a thin section of the North Lisbon rock, and is magnified 35 diameters. It shows the color of the hornblende, which, while dark in the mass, is very prettily green when made so thin. The hornblende is generally fibrous, and is found in large crystals, yet microscopic crystals are always scattered through the feldspar, as shown. The mica is biotite and very dichroic, becoming nearly black with a quarter revolution of one nicol. A round grain of quartz is seen in the middle of the feldspar, and the feldspar when placed between the nicol prisms is found to be triclinic.

To the chemical variations reference has already been made. To serve as a basis for calculation, the hornblende contained in a dioryte from North Lisbon was analyzed. In it the hornblende in places had crystallized out in large orbicular masses half an inch in diameter. It appears under the microscope in color and structure like the large crystal in the section figured. The crystals are fringed on the edges, and consequently on the outside are intimately mixed with feldspar; but in the middle they are pure, as was proved with the microscope. A portion of the hornblende free from associated ingredients was analyzed with the following results:

Silica	49·03
Alumina	13·72
Ferrous oxide	9·84
Manganous oxide	·40
Lime	11·22
Magnesia	11·96
Soda	2·40
Water (ignition)	·90
	99·47

This analysis shows that these diorytes have a highly aluminous hornblende, resembling in all respects some kinds of the variety called pargasite. I would refer to the analyses published upon page 238 of the fifth edition of Dana's Mineralogy. That hornblende can thus take into its composition so much alumina and alkali shows under what varying conditions of composition this mineral may be formed. An analysis of the rock from North Lisbon gave 51·25 per cent of silica, while another containing the same variety of hornblende gave 55·62 per cent. In the former the feldspar is labradorite, and the amount of silica in the latter seems to imply that it is probably part or all oligoclase.

In some places the dioryte develops a well defined schistose structure, and thus becomes *diorytic schist.* The microscope is unable to detect a great difference in composition; it only indicates a more finely fibrous and more diffused hornblende, less feldspar, and more grains of quartz. This rock is very common at Cornish. By further addition of quartz and diminution of the feldspar this rock graduates into hornblende schist.

2. *Metamorphic Diabase.*—Hydrous rocks are very common in this region, in which chlorite is a prominent ingredient. They generally contain pyroxene and sometimes hornblende. These rocks like the hornblendic are both massive and schistose. The massive rocks, having labradorite in addition to the minerals above enumerated, are *metadiabase.* They are very extensively developed in the extreme north, but are common as far south as Hanover. They are often quite complex in structure, but, as in the case of igneous diabase,* the chlorite imparts to the rock a light green color which makes it easily distinguishable from the diorytes. In plate V, figure 2. the microscopic structure of this rock is represented. The figure is drawn from a section of a specimen from Littleton, and is magnified 35 diameters. The chlorite in these rocks has usually an amorphous appearance, occurring, as shown in the figure, in irregular masses, with little appearance of structure; yet, as it exhibits bright colors between crossed nicols, it is all

* This Journal, vol. ix, March, 1875.

crystalline. The pyroxene shows the characteristic cleavage, as indicated in the figure and also exhibits bright colors between the nicols, such as are seen in the pyroxene of figure 4. The feldspar looks impure and is filled with rifts and with numerous particles of chlorite and amorphous matter yet shows its characteristic bands of color between the nicol prisms. Hornblende sometimes replaces the pyroxene in these rocks, and is often present with it. The occurrence of these two minerals in the same rock is interesting, and the following analyses throw some light upon it. The first one is of a wholly chloritic kind, from Littleton; while the latter, from Pittsburg, is of a variety containing hornblende. The specific gravity of each is 2·96.

	Littleton.	Pittsburg.
Silica	45·56	48·79
Alumina	16·57	16·97
Ferric oxide	·36	1·69
Ferrous oxide	9·40	8·97
Manganous oxide	·20	·20
Lime	8·01	9·98
Magnesia	10·34	6·98
Potash	1·20	
Soda	2·55	3·30
Titanic acid	1·20	1·10
Water	3·93	2·65
Carbonic acid	1·02	
	100·34	100·63

On comparing these two analyses, little difference is seen between them, or between them and the corresponding igneous rocks. It will only be noticed that the one which is the more chloritic contains, naturally, more water and magnesia and less silica; hence, if in the rock represented by the second analysis the same chlorite was formed, and its amount was limited by the amount of water, there would be left a residue (corresponding to the remainder of chlorite in the first rock), which would make an aluminous hornblende; for there is little difference between the hornblende of which an analysis is given on page 132, and some chlorites save in the greater percentage of silica, and smaller of water, for the lime and magnesia are capable of replacement in either the hornblende or pyroxene. The conditions for the formation of both hornblende and pyroxene in a rock will be made a subject of further study. It seems to me to be dependent upon a low grade of metamorphism at a temperature below that which would have converted all into pyroxene and above that which would have determined it all to be hornblende. In view of the fact that the hornblende of

these rocks contains so large a proportion of alumina and also alkali, it will be seen how many combinations could be made from the same material. They both contain about two per cent of titanic iron and the oxygen ratio of the whole makes it probable that the feldspar is labradorite. There is present also some pyrite, and apatite or some mineral phosphate. For analysis, portions of the rock free from pyrites were selected; the phosphoric acid was not determined, but it was found to be present when a careful test was made, and the microscope reveals some minute crystals which appear like apatite.

3. *Organic remains in the metadiabase.*—In the microscopic study of these massive chloritic rocks, or metadiabase, I have found certain forms which appear to be of organic origin. Two of them are figured on plate V, in figs. 5 and 6.

Figure 5 represents a specimen from the metadiabase of Connecticut lake in Pittsburg. It has the structure of a tabulated coral, resembling much a *Chætetes*;* but on account of its minuteness, in connection with other characters, there is little question but that it is a fragment of a rhizopod mass or foraminifer; and a close resemblance to a *Stromapora* will be noticed. The figure, like all the others, is drawn from a thin section of the rock, magnified thirty-five diameters. The breadth of the cells is hence but $\frac{1}{250}$ of an inch. These forms seem to be abundant in the rock; for, in a section of a fragment of rock half an inch square in surface, several bits of the fossil are sometimes found. The specimen figured is the most perfect that I have seen; but smaller fragments are abundant, and as they are apparently alike in dimensions, they sustain the supposition of the organic origin of all.

In the metadiabase of Hanover another form was found, which is represented in figure 6. This is very likely a section of a fragment of the same species of rhizopod cut in a different direction.

These forms, distributed through the massive rock, have a structure, as the figures show, which cannot be attributed to crystallization. They seem to make it evident that rhizopods must have been living over the sea bottom during the accumulation of these sediments, and became buried in the mud which is now the material of the rock. These forms are composed of silicates, but of what precise kind it is difficult to determine, since the particles are minute and their optical properties are obscure. Yet upon placing a drop of acid upon one of them it effervesced for a short time, showing that carbonate of lime existed in it—perhaps part of that of the original foraminifer.

The presence of these remains of rhizopods in the metadia-

* It also calls to mind the series of cells of a Bryozoan. See figures of *Lichenalia concentrica*, Plates 37 A and 40 E, Natural History of New York, Part VI, Palæontology, Vol. 2, by James Hall.

base is additional evidence of the sedimentary origin of these rocks; and they also confirm the view that the metamorphism was feeble in its degree, since it allowed of the preservation of these forms. It suggests, moreover, a source for the lime of the labradorite and other minerals of the rock, as well as for its pyrite and phosphate. Associated with these rocks are extensive beds of argillytes, which are scarcely altered. Everything points to quiet waters during the original deposition; and finally to gentle metamorphism.

4. *Chlorite Schist. Metadiabase Schist.*—Metadiabase, by the development of a schistose structure, becomes metadiabase schist; or, as it is commonly called, chlorite schist. This rock is very abundant everywhere in the formation. It is schistose, but the laminæ are often so firmly united that its structure is manifested only on fracture. It is distinguished from hornblende schist by its light green color, and by giving off water when heated. Under the microscope the chlorite is crystalline and strongly dichroic. Its crystals are mostly in the plane of lamination, and the pyroxene is in minute particles. A specimen from Hanover, having a gravity of 3·03, was analyzed, by Mr. Pease of the Sheffield laboratory, with the following result:

Silica	46·55
Alumina	19·26
Ferric oxide	2·58
Ferrous oxide	9·73
Manganous oxide	·25
Lime	9·07
Magnesia	6·67
Potash	·09
Soda	3·31
Titanic acid	·52
Water	2·39
	100·42

This rock which, as the microscope shows, contains but little titanic iron, yet has more than twelve per cent of oxides of iron; and hence the analysis indicates a ferruginous chlorite containing but little magnesia. The chlorite which best fulfills the conditions of composition and optical properties is the one which occurs in igneous diabase—the diabantite;* and which is very apt to be formed in ferruginous rocks. If we consider the water as an index to the amount of this chlorite, and the remaining magnesia to indicate pyroxene, we find that the rock consists of 25 per cent of chlorite, 20 per cent of pyroxene, 1 per cent of titanic iron, and a residue nearly identical in composition with labradorite. These schists are sometimes highly

* This Journal, vol. ix, June, 1875.

porphyritic, and sometimes large crystals of feldspar are sparsely scattered through the mass.

Some of the metadiabase schist resembles closely specimens of the German *schalstein*, which like these is often associated with massive diabase, but which is considered to be the consolidated tuff that has resulted from the wear and tear of the massive igneous rock. The New Hampshire rock, as all the facts show, is unquestionably a result of the metamorphism of sediments, like the others of the greenstone series. These stratified kinds give us the plainest conceptions of the mode of origin of the whole.

5. *Metamorphic Doleryte.*—There is one more massive rock to which I refer on account of its lithological interest. It is the compound of pyroxene, triclinic feldspar and titanic iron, which is found at Littleton. The rock has the composition of a doleryte. Yet it contains diallage, or foliated pyroxene in large individuals, and hence it would be generally called gabbro. As the crystalline condition of the pyroxene seems to be an unimportant distinction, I here refer it to *metadoleryte*. The color of this rock is quite dark gray, and large orbicular crystalline masses of diallage are developed in a finely granular base. Its composition is as follows:

Silica	40·25
Alumina	13·62
Ferric oxide	5·46
Ferrous oxide	10·36
Lime	10·31
Magnesia	8·86
Potash	·59
Soda	1·96
Titanic acid	6·53
Water (ignition)	·74
	98·68

The microscopic structure of this beautiful rock is illustrated in figures 3 and 4 of Plate V. Fig. 3 represents the appearance of a thin section magnified thirty-five diameters, by ordinary transmitted light, while fig. 4 represents the appearance of the same between crossed nicol prisms. It contains as the figure and analysis show, a large amount of titanic iron, and hence the low percentage of the silica. Fig. 4, which illustrates the effect of polarized light shows the banding of the feldspar, which is either labradorite or anorthite. But the thing of most interest is the association of hornblende with the pyroxene. It is quite evident from a study of the section that the colored mineral was originally all pyroxene, and that it has now been partly changed into hornblende. That the horn-

blende resulted from the pyroxene is shown by the spots of hornblende in the pyroxene; the outline of these altered spots is quite indefinite and indistinct, indicating plainly the fact of change. When change of species takes place with no change whatever of chemical composition, it does not follow that the alteration should begin at the outside as in other cases, and as here seen this change began at the middle. Other crystals are seen to have so completely changed as to develop beautifully the cleavage of hornblende, while at the same time a good illustration of the cleavage of pyroxene is seen in the same slide. This alteration, which is not uncommon in other regions, is of much importance in New Hampshire, for in nearly all the trap rocks, the same change has taken place. It will be noticed that the pyroxene changes into a yellowish-brown strongly dichroic hornblende, and not into the bright green one which characterizes the original diorytes.

6. *Argillyte.*—In closing, I give an analysis of one of the non-crystalline rocks which abound in the region, in support of some of the views that have been advanced. The one that I select is from Woodville, and is a corrugated argillyte. The composition obtained is as follows:

Silica	60·49
Alumina	19·35
Ferric oxide	·48
Ferrous oxide	5·98
Lime	1·08
Magnesia	2·89
Potash	3·44
Soda	2·55
Water	3·66
	99·92

In this rock the microscope shows only incipient crystallization; yet it has a composition that would have made a good granite if circumstances had favored; but owing to the feeble degree of the metamorphism, the sediments of this composition were well nigh unaffected. The reason for this is seen in its small percentages of lime, magnesia and iron.

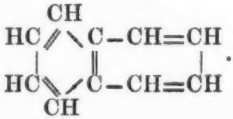
In conclusion, it appears from the facts described, that the greenstones of New Hampshire have been formed from fine sedimentary deposits which were accumulated in still waters; that the metamorphic action under which they were consolidated was quiet or gentle in degree, far different from that which in the adjoining regions has formed mountain masses of granite and gneiss, and hence that their special location in the region of metamorphic action, in connection with the nature of the sediments, has determined the characters of the greenstone series.

Sheffield Laboratory, New Haven, Conn.

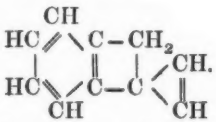
SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

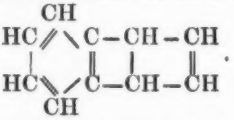
1. *On the constitution of Naphthalene.*—The constitution of the hydrocarbon naphthalene has been fixed, from its close analogy with benzene, as follows:—



Wreden has recently proposed two other formulas for this substance and has given his reasons for preferring them. These rational formulas are both unsymmetrical. The first is the most important, and is:—



The arguments offered are: 1st, the important pyrogenesis of naphthalene observed by Berthelot from styrene and ethylene, showing that the latter grouping is present. 2d, the decompositions of its molecule by oxidation and reduction. 3d, the mutual formation of decahydronaphthalene and hexahydrocymene by the reduction of naphthalene. 4th, the four possible monosubstitution derivatives indicated by the above formula, three of which have already been obtained. 5th, the formation of unsubstituted phthalic acid from dichlornaphthoquinone and of tetrachlorphthalic acid from pentachlornaphthalene is no evidence for the correctness of the symmetrical formula. 6th, the existence of two perchloronaphthalenes. And 7th, the existence of two analogous compounds, isomeric with styrene and acetenylbenzene, which this theory foresees may be synthesized from benzene and ethylene. The second formula, isomeric with the first, is:—



It differs from the symmetrical formula only in the mode of combination of the carbon atoms. Arguments 1, 4, 5, 6, and 7 apply also to it.—*Ber. Berl. Chem. Ges.*, ix, 590, May, 1876. G. F. B.

2. *Conversion of normal into iso-butyric acid.*—Erlenmeyer has observed a remarkable conversion of normal into isobutyric acid. In order to show the curious inversion of solubility in hot and cold water of calcium normal butyrate and isobutyrate, he

sealed up in glass tubes a cold saturated solution of the former and a hot saturated solution of the latter. This last tube on cooling deposited crystals while the first tube did the same on heating. After repeating the experiment for class instruction many times, the quantity of the normal butyrate crystals appeared to lessen on heating, and on strong cooling crystals appeared resembling the isobutyrate. This result careful examination confirmed. Since boiling for eight days did not effect the change, time must be the requisite.—*Liebig's Ann.*, clxxxi, 126, May, 1876. G. F. B.

3. *On the Influence of Asparagin on Saccharimetry.*—Champion and Pellet have studied the influence exerted by the rotatory power of asparagin upon the indications of the saccharimeter. Its aqueous solution (containing when saturated 1·66 to 1·72 per cent) rotates the yellow ray $-6° 14'$; after adding ten per cent of ammonia $-10° 41'$. For white light the rotation $-11° 23'$ was obtained, corresponding closely with that of M. Bouchardat, $-11° 18'$. On adding a mineral acid, the sign changes. An aqueous solution of asparagin containing 10 per cent of hydrochloric acid, has a rotatory power of $+37° 27'$ for the yellow ray. Now since Dubrimfaut has shown that beet roots contain 2 or 3 per cent of this substance, the indications of the saccharimeter are somewhat too high, since the juice, although alkaline after clarification with basic lead acetate, still has a plus rotatory power. This error may amount to 0·7 gram of sugar in the 100 c.c. The authors find, however, that the rotatory power of the asparagin is entirely destroyed by the addition of acetic acid. They recommend the addition to the solution, after treatment with the basic acetate, of 10 c. c. of acetic acid (at 8°) to every 100 c. c. The same fact to a less degree is true of the juice of the cane. The authors propose the titer before and after the addition of the acid, as a method for estimating asparagin.—*C. R.*, lxxxii, 819, April, 1876. G. F. B.

4. *On the Alkaloid Aricine and some related Bodies.*—Hesse has subjected to a new and exact investigation the cinchona alkaloid discovered in 1829 by Pelletier and called aricine, obtained from a new bark *Cinchona pelleteriana.* He comes to the conclusion that aricine, as well as the cinchovatine of Winckler, and a new lævo-rotatory alkaloid discovered by de Vrij in 1873, are identical in the pure state with cinchonidine. The alkaloid called aricine by Howard, was probably paricine containing cinchonine. —*Liebig's Ann.*, clxxxi, 58, May, 1876. G. F. B.

5. *Analysis of Mixed Liquids.*—Dr. Siemens has designed an instrument by which a stream of alcohol and water mixed in any proportion, is measured in such a manner that one train of counter wheels records the volume of the mixed liquid; while a second counter gives a true record of the amount of absolute alcohol contained in it. The principle on which this measuring apparatus acts may be shortly described thus: The volume of liquid is passed through a revolving drum, divided into three compartments by radial divisions, and not dissimilar in appearance to an ordinary wet gas-meter; the revolutions of this drum produce a

record of the total volume of passing liquid. The liquid on its way to the measuring drum passes through a receiver containing a float of thin metal filled with proof spirit, which float is partially supported by means of a carefully adjusted spring, and its position determines that of a lever, the angular position of which causes the alcohol counter to rotate more or less for every revolution of the measuring drum. Thus, if water only passes through the apparatus the lever in question stands at its lowest position, when the rotation motion of the drum will not be communicated to the alcohol counter, but in proportion as the lever ascends a greater proportion of the motion of the drum will be communicated to the alcohol counter, and this motion is rendered strictly proportionate to the alcohol contained in the liquid, allowance being made in the instrument for the change of volume due to chemical affinity between the two liquids. Several thousand instruments of this description are employed by the Russian Government in controlling the production of spirits in that empire, whereby a large staff of officials is saved, and a perfectly just and technically unobjectionable method is established for levying the excise dues. —*Nature*, xiv, 58. E. C. P.

6. *Viscosity of Salt-Solutions.*—M. Grotrian has determined the constants of friction of some salt solutions and their relations to galvanic electricity. The oscillations of a suspended disc with attached magnet (under the influence of a neighboring magnet) were observed in air and in the liquid under examination. The observed generally similar curve of temperature coefficients for fluidity and galvanic conductivity, with change of concentration, leads the author to conclude that the overcoming of internal friction forms an essential part of the work done by a current in passage through an electrolyte. In the case of chloride of potassium it is found that the increase of conductivity is almost exactly proportional to the percentage proportion (in the liquid); and Mr. Grotrian infers that the chemical changes he conceives generally to occur in chemical constitution of electrolytic molecules, on altering the concentration, do not occur here, but that with varied concentration, at the same temperature, the conductivity is only conditioned by the proportion of salt and the viscosity. With the numbers obtained in the experiments, it is possible to estimate for variously concentrated solutions of a salt, the temperatures for which the constants of friction have some determinate constant value; then to calculate the numbers for the conductivity at this temperature, and inquire according to what law these alter with the concentration. He thus shows that in the case of NaCl, KaCl, $CaCl_2$, and $BaCl_2$ the concentration and the viscosity are the principal factors, which determine the amount of the conductivity. —*Pogg. Ann.*, clvii; *Nature*, xiv, 142. E. C. P.

7. *Viscosity of Gases.*—Herr von Obermayer has recently communicated a memoir to the Vienna Academy on the relation of the coefficients of internal friction of gases to the temperature. If we accept for the coefficients of friction μ at $t°$ C. the formula

$\mu=\mu_0(1+\alpha t)^n$ while α is the coefficient of expansion of the gas taken as a basis of the calculation, then the experiments of Obermayer give the following values of n:—Air, 0·76; hydrogen, ·70; oxygen, ·80; carbonic oxide, ·74; ethylene, ·96; nitrogen, ·74; protoxide of nitrogen, ·93; carbonic acid, ·94; ethyl chloride, ·98. The coefficient of friction of the permanent gases is, according to these experiments, approximately proportional to the $\frac{3}{4}$ power and that of the coercible gases to the 1-power of the absolute temperature.

For temperatures between 150° and 300° C. air gave the same values of n as between the lower temperatures −21·5 and 53·5. In the case of carbonic acid a slow decrease of the exponent n. with the temperature was perceptible from the experiments.—*Nature*, xiv, 119. E. C. P.

8. *Simultaneous Sounding of two Notes.*—Dr. R. König sums up the results of an elaborate series of experiments of the effect of two tuning forks sounded together as follows:

I. (1) The number of beats of two notes n, n' is always equal to the positive and negative remainder of the division $\frac{n'}{n}$; that is, equal to the numbers m, m', which are produced by stating $n'=hn+m=(h+1)n-m'$, while n, n' are the number of double vibrations, and h the quotient of the division which gives the remainder m. It is as if the beats proceeded from the two overtones h and $h+1$ of the lower note n, between which the higher note n' lies. The cause of the beat-notes is simply the periodical coincidence of the common maxima of the two sound-waves.

(2) The beats of the pure harmonic intervals can be heard in the relations 1 : 8 and even 1 : 10, and may, as well as the beats of the unison, be regarded as resulting directly from the composition of the vibrations of the primary notes, without the help of resultant intermediate notes, whose existence cannot be proved.

(3) Both the beats m and the beats m', not only of the interval $n : n+m$, but also of the interval $n : hn+m$ ($h=2, 3, 4$), when the intensity of the primary notes and their number are sufficient, change into beat notes.

II. (4) When the two beat-notes m and m' are near the unison, the octave, and the twelfth, the same beats may be heard as would be produced by two equal primary notes. I have named these beats arising from beat-notes secondary beats, in order to distinguish them from the beats arising from primary notes.

(5) When the intensity of the beat-notes by which they are formed and their numbers are sufficient, these secondary beats change to a secondary beat-note, as primary beats change to a primary beat-note.

III. (6) The difference-notes and summation-notes, which are produced by the change of two loud notes (the vibrations of the latter not being infinitesimal), produce a phenomenon which is independent of the beats and beat-notes; they are only much weaker than the beat-notes.

IV. (7) The beat-notes cannot be explained by reason of the difference-notes and summation-notes, because the number of their vibrations is in many cases different from what this cause might produce.

(8) The audibility of the beats depends solely upon their number and upon the intensity of the primary notes, and is independent of the distance of the interval.

(9) The number of the beats and of the primary impulses in which both may be perceived as separate impulses is the same.

(10) With the beats perceived as separate impulses, as with the primary impulses perceived in the same manner, the note which approaches them in number is audible.

(11) The number at which beats and primary impulses can change into one note is the same.

(12) As with beats and primary impulses, the intermissions of a note can also change into one note.

(13) When the vibrations of a note vary periodically in intensity, the periodical maxima of vibration change into one note, if their number is sufficient.

(14) The beat-note which is formed by two primary notes must always be weaker than the latter, although single beats are stronger than the notes which form them.—*Phil. Mag.*, l, 417, 511. E. C. P.

II. Geology and Mineralogy.

1. *Critical Observations on Theories of the Earth's physical evolution;* by Capt. C. E. Dutton. (The Penn Monthly, May and June, 1876.).—Captain Dutton presents in this paper the views brought out in his article in volume viii of this Journal, with fuller illustrations, and adds explanations of his theory of the origin of mountains. The discussion should be read by all desiring to reach right conclusions, it presenting many arguments from physical considerations against the contraction-theory, or that of the uplifting and folding of strata through lateral pressure. There is much to be learned before any theory of mountain-making shall have a sufficient foundation in observed facts to demand full confidence, and Captain Dutton merits the thanks of geologists for the aid he has given them toward reaching right conclusions. His discussions are not free from misunderstandings of geological facts, and if they fail to be finally received it will be for this reason. The subject is too large a one for a full statement, in a book-notice, of the apparent difficulties and sources of doubt which might occur to an advocate of the latter theory.

We here give in a brief form, and nearly in his own words, the principal points in his theory of mountain-making as explained in the later part of his memoir.

Accepting the proposition that there is a plastic condition of rock beneath the earth's crust and that metamorphism is a "hydrothermal process," and believing that "the penetration of water to

profound depths [in the earth's crust] is a well sustained theory," he says that great pressure and a temperature approaching redness are essential conditions to metamorphism; that the state of silica, alumina, etc., in the process, is like that when these oxides are obtained in the soluble hydrous condition, and therefore they would have had less specific gravity than they have in the crystalline anhydrous condition; and that a diminution of heat or pressure would have been followed by crystallization and an increase of density; that the deeply buried rocks would require but little expansion to cause a diminution of specific gravity; and, if they become highly plastic from any cause, then the position of the superior or overlying strata would be one of unstable equilibrium; if heated without becoming plastic, or if plastic and yet denser than the overlying beds, the expansion would cause a vertical upward movement and attendant results, including in some cases great fractures owing to inequalities in bedding and texture and the consequent unstable equilibrium; that the axes of maximum deposit would become the axes of future synclinals, because "the heaviest portion would sink into the lighter colloid mass" underneath, protruding it laterally beneath the lighter portions where, by its lighter density, it tends to accumulate." He adds: "The resulting movements would be determined, first, by the amount of difference in the densities of the upper and lower masses, and, second, by inequalities in the thickness of the strata: the forces now become adequate to the building of mountains and the plication of strata, and their modes of operation agree with the classes of facts already set forth as the concomitants of those features."

The views are next applied to a system of plications. "It has been indicated that plications occur where strata have rapidly accumulated in great volume and in elongated narrow belts; that the axes of plications are parallel to the axes of maximum deposit; and that the movements immediately followed the deposition"—the case of the Appalachians being an example in which the accumulations averaged 40,000 feet. He observes: "Wherever the load of sediments becomes heaviest, there they sink deepest, protruding the colloid magma beneath them to the adjoining areas, which are less heavily weighted, forming at once both synclinals and anticlinals. If the difference in the densities of the upper and lower portions be small, the latter being a little less or but slightly plastic, the disturbance would not be great [and the undulations made would be low]; if this difference and the plasticity be considerable, the disturbance becomes not only greater, but assumes new phases [as in the Juras and Appalachians]; and finally when the two conditions become extreme, the phenomena become eruptive." The movements are hence according to hydrostatic law. He says further: "In mountain-making the disturbing agents have been extreme. All typical mountains consist of granitoid cores protruded through strata and towering above them"—as in the Sierra Nevada. "The thickness of the

Appalachians is from five to eight miles; the thickness of the Miocene strata of the Coast Range in California, according to Messrs. Brewer and King, is nearly five miles [5000 feet?]; and both systems bear every indication of being shallow-water deposits —in brief, coast and off-shore deposits. No geologist doubts that these strata subsided as they grew in thickness. But if they subsided they displaced the matter beneath them; and what becomes of the displaced matter?" In the case of the Appalachians "it must have gone to the south-eastward—toward the land whence the sediments were derived"—"the direction toward which gravitation would inevitably propel it." "In the Coast Range, the Uintahs, Wahsatch and the Park Mountains of Colorado, strata miles in thickness have sunk, and right at the upturned edges come up the towering granitoid mountains." "On the one hand, matter has been displaced and gone somewhere [southeastward], on the other, displaced matter stands revealed in immediate contiguity." The Uintah range is a good example. "Disregarding the enormous Cretaceous deposits, the freshwater Tertiaries turned up on the flanks of these mountains are 10,000 feet thick. That these beds subsided by their gross weight as rapidly as they grew admits of no shadow of doubt." "What became of the matter displaced by the sinking strata, and whence came the displaced matter which slopes down to their upturned edges, and how can the conclusion be avoided that they are one and the same?" In other words the granitoid core was extruded as the sinking went forward, or during the later part of it.

For further details respecting the theory we refer to the original memoir.

With regard to this new theory, we might reasonably question the existence of the colloid magma—a condition fundamental to the theory—and his evidence that water penetrates to profound depths in the earth's crust sufficient to make hydrous rocks. We might ask for evidence that the rocks beneath the Cretaceous and Tertiary, and other underlying strata of the Uintahs, were in such a colloid state, and this so near the surface, that the "beds subsided by their gross weight as rapidly as they grew." We might query whether, if the subsiding of the beds were causing at the same time a protruding, the seas would have been in a condition for living species or quiet deposition, and whether therefore the protrusion, if a fact, must not have been a final result after the deposition and the attendant subsiding had ended. We might query whether the granitoid core of some of the mountains referred to has been proved to be of the age the theory assumes. We might query also whether in the case of the Appalachians, the material of which the rocks were made came from land once existing to the southeastward; whether the various anticlinals and synclinals in different overlapping series, taking only the larger ones, could have corresponded severally to movements in a colloid mass below, to a sinking by weight where the material was thickest above, and so making the synclinals; whether in the case of the Appalachians,

the width of the synclinal formed as the Paleozoic deposits were in progress was not approximately as great as the width of the area of thickening depositions, and whether the anticlinal, made by the displaced plastic material beneath being pushed to the southeastward, was not at least as broad as the synclinal, so that one anticlinal and one parallel synclinal may have occupied together three hundred miles or more in breadth.

Captain Dutton observes that "plications occur where strata have rapidly accumulated in great volume," etc. This idea of *rapid* accumulation and brief work in mountain-making has occasioned, as shown in this and some other parts of his memoir, some misapprehension of the effects that would come from lateral pressure. The accumulation of material for the Appalachians, occupied the whole of Paleozoic time; and probably there is no geologist who believes that the length of that era was less than ten millions of years, and few that it was less than fifty millions. Even if it took one million, the accumulation was not rapid; and certainly not if it took fifty millions. Again, he says that the movements of mountain-making "immediately followed the deposition." "Immediately" sounds quick to one who appreciates the slowness of geological changes. The Carboniferous age was very long; and somewhere in that part of geological time, either before the age had fully ended, or some time after its close, the epoch of catastrophe began. But this catastrophe, according to the apprehension of geologists who best appreciate the rate of the earth's progress, may have taken one or more hundreds of thousands of years to have accomplished its results—time enough to have produced plications without chaotic effects.

2. *A Report on the Invertebrate Cretaceous and Tertiary Fossils of the Upper Missouri Country;* by F. B. MEEK. 609 pp. quarto, with an Introduction of lxiv pages, and 45 quarto lithographic plates, of about 1000 figures, constituting volume ix of the Report of the U. S. Geological Survey of the Territories, F. V. HAYDEN, U. S. Geologist in charge.—Mr. Meek's labors in connection with the Cretaceous and Tertiary fossils of the Rocky Mountain region began more than thirty years since, and, with some interruptions by work on the paleontology of other parts of the country, they have been continued ever since. He was engaged in the descriptions of the earliest invertebrate fossils collected in Nebraska by Dr. Hayden, and has always been referred to for descriptions of the species of the expeditions under Dr. Hayden's charge, and not of these alone. For the preparation of this new and great work he has therefore had the benefit of his previous long and labored study of the subject, and the command of all the species the Rocky Mountain expeditions have afforded. Mr. Meek works with extreme care and fidelity, and hence his results rank with the best.

The country in which the fossils described in his work were discovered lies mainly between the British possessions on the north, the Platte on the south, the Missouri River on the east and the Rocky Mountains on the west.

The Introduction to the volume, after presenting sketches of the earlier explorations in the Upper Missouri region, describes the formations from which the fossils were collected, giving sections showing the thickness and order of superposition of the various subdivisions. The geographical extension of the same west of the Mississippi is also shown; and their relation to the subdivisions of the Cretaceous in Mississippi, Alabama, New Jersey, and in the Old World are fully discussed. The author also makes some remarks on the mooted question in regard to the relation of the Lignites of the far-west to the Cretaceous and Tertiary systems, maintaining, as he had previously done, that these deposits belong in part to the Cretaceous and in part to the Tertiary: that is, that the beds at Coalville, Utah, and Bear River, Wyoming, are clearly Cretaceous, like those of Western Colorado; that those of Bitter Creek, Wyoming, especially those below the horizon of the Hallville coal, are almost certainly Cretaceous; that those above, to the horizon of the Saurian bed at Black Butte Station inclusive, probably belong also to the Cretaceous, but may be Eocene; and that the Evanston and Carbon Station coal-bearing strata of Wyoming are Tertiary.

The Judith river fresh- and brackish-water beds of Montana, and of British America, in which Cretaceous types of Saurians have been found, along with some Eocene types of vertebrates, and new species of shells that would be called Tertiary forms by almost any paleontologist (judging from their affinities), he thinks, *may* be Cretaceous, but he does not regard this conclusion as yet clearly established. The Fort Union fresh- and brackish-water Lignite group, of the Upper Missouri he regards as Tertiary.

In the body of the work, all of the known Upper Missouri invertebrate genera, subgenera, species and varieties, whether new to science or not, are fully described; and are also illustrated on the accompanying plates. The genera thus described number about 120, the subgenera, including the type sections, 170, and the species and varieties about 308. Full synonymy and references of all of the species and genera are given, and the type of each genus and subgenus, where known, is mentioned; and, where there is doubt as to the exact type-species, a typical example is cited. After the description of each genus a separate brief diagnosis of its subgeneric sections (if so divisible) is given, and an example cited.

The affinities and geological range, so far as known, of each genus, are also fully discussed; and when represented by existing species, its habits and geographical distribution are generally stated. Most of the species, and some of the genera in the work, are here for the first time illustrated.

Only a few of the species are known to occur in the old world, and at localities in this country east of the Mississippi; and these are all from the Cretaceous, and show that the Niobrara and Fort Benton Groups, as well as perhaps the Dakota Group, represent the Lower or Gray Chalk, with possibly also the Upper Green Sand;

and the Fort Pierre and Fox Hills Groups the Upper White Chalk, and, possibly, also the Maestricht beds of Europe.

3. *Shower of Volcanic dust over Scandinavia.*—In March of 1875, according to A. E. Nordenskiöld, a shower of volcanic dust fell widely over Sweden and still more abundantly over Norway, making a layer over some places a quarter of an inch thick. The dust was pumice-like in constitution. It is traced to Iceland. On the 30th of March the winds were northwest and west. An eruption began in Iceland in the preceding December, from numerous craters in the interior, and the most abundant ash-shower occurred over the island on the 29th of March, covering some pastures six inches deep; and if the ashes of the same shower reached Scandinavia, as is probable, the journey of 2000 kilometers was performed in less than twenty-four hours.— *G. Mag. for July.*

4. *Carrara Marbles.*--Prof. G. A. Lebour, in the Geological Magazine for July, mentions the discovery of Sub-carboniferous fossils in connection with Carrara statuary marbles; among them *Spirifer glaber*, *Leptæna arachnoidea* d'Orb., *Cardiomorpha pristina* de Kon., *Cardinia tellinaria* de Kon., *Pholadomya regularis* d'Orb., *Cyathocrinus quadrangularis* Miller, etc. The superior Coal-measure shales, at Monte Jano, contain *Neuropteris rotundifolia* Brngt., *Odontopteris Schlotheimii*, *Pecopteris arborescens*, *P. cyathea*, *Cyclopteris orbicularis*, *Annularia longifolia*, etc.

The St. Béat marbles, in the Pyrenees, are of the same Carboniferous limestone age.

5. *Markings supposed to have been made by man with stone implements on bones of a Balænotus of the Lower Pliocene of the valley of Fine, Italy.*—Capellini who described these markings to the R. Accademia dei Lincei, at the meeting of May 7th, states that the Balænotus was the same species described by Van Beneden from the Tertiary of Belgium. The marl-bed, containing the bones, he identifies with the Superior marl of the Vatican, belonging to the Lower Pliocene. His memoir will soon be published, with a plate.

6. *Serpentine and Eozoon.*—Dr. Dawson has a reply to the criticisms of Mr. Hahn, in the number of the Annals and Magazine of Natural History for July, and Dr. William Carpenter in the number for June. Dr. Carpenter mentions the discovery, by Prof. Möbius, of Kiel, in 1874, on a coral reef off Mauritius, of an incrusting foraminifer, which, in mode of growth and peculiarities of structure, approaches rather closely the Eozoon.

Dr. Dawson states that Mr. Richardson has found at Chibogomon, Canada, in a great bed of olive-green serpentine (a kind analyzed by Hunt) a specimen of tabulate coral, having many of its thin-walled hexagonal cells filled with serpentine, while others were filled with chlorite; and that a dark-green serpentine from Melbourne, Canada, envelopes fragments of shells, crinoids and corals, and also penetrates their pores and cavities.

Dr. Dawson has described (Quar. Jour. Geol. Soc., Feb., 1876) specimens of *Eozoon Canadense* from Côte St. Pierre, in the

Seigniory of Petite Nation, on the Ottawa, in a limestone of the Grenville band of Sir W. E. Logan, resting on bedded dioryte. Serpentine occurs in the limestone with the Eozoon, and also there is some dolomite, much of it without the Eozoon structure.

7. *Experiments on Schistosity in rocks, and on the deformations of fossils attending its production;* by M. DAUBRÉE (C. R., lxxxii, March 27 and April 10, 1876.)—The production of foliation in rocks is here discussed at length and illustrated by facts from experiments; and the results are made by Daubrée to include all examples of a schistose structure. His experiments were made by the hydraulic press used by M. Tresca in similar researches, and under the advice of this physicist. Clay containing fine sand forced through a cylindrical aperture was rendered foliaceous concentric with its surface; and if mica were mixed with it, the foliaceous structure was very perfect, the mica scales having taken a position parallel to the surface. The same micaceous clay forced through a rectangular aperture became foliaceous parallel to the surfaces of the rectangular prism obtained, the most of the mica being parallel to the larger faces. The larger the scale of mica the more perfect the parallelism. These clays thus made foliaceous called to mind, strongly, M. Daubrée observes, the foliaceous character of mica schist and gneiss. By the same process, the compression of fossils was illustrated and also the occasional subdivision of one into a series of separated parts. A belemnite was too firm to answer for the experiment; but a piece of chalk cut into the form of a belemnite. gave precisely the fracture and separation of parts so often seen.

Daubrée states that in the production of the foliated or schistose structure, there is a sliding of the parts unequally *in the direction of the pressure and movement;* and this is its origin. It is not necessary that the substance should consist of visible particles; for Tresca obtained the structure even with metallic lead. Moreover a very slight movement is sufficient to produce a distinct foliation; and a slow one conducts to the same result as a rapid.

From the experiments Daubrée draws the wide conclusion that the schistose structure in gneiss and mica schist, as well as that seen less perfectly in some granite, may have been produced *by pressure and movement;* and that in the region of Mont Blanc, for example, movement under pressure of the protogine material when pressed out in a plastic condition was the cause of all the schistosity the rock presents.

Where gneiss, mica schist, quartzyte, limestone occur in alternating beds, as is often observed, with the foliation parallel to the planes of junction, they must of course be regarded as successive strata, and as foliated parallel to the bedding in consequence of the original bedding. This is sometimes proved to be the case by the presence of more or less perfect fossils in the limestone. Hence, the question whether in any special case, the schistose structure of gneiss or mica schist was occasioned by pressure or not, is to be ascertained by a direct study of the rocks in place.

8. *The Geological and Natural History Survey of Minnesota;* 4th Annual Report, for 1875; by N. H. WINCHELL, State Geologist, assisted by M. W. HARRINGTON. 162 pp. 8vo. St. Paul, Minn. 1876.—This report contains a Report on Fillmore County, by Prof. Winchell, and others, on Olmstead, Dodge and Steele Counties, by Mr. Harrington, together with a long table of railroad elevations, and a Report on the General Museum, by Prof. Winchell. Colored geological maps are given of each of the above named counties, and also good illustrations of some of the rock-scenery. One of the latter represents a bluff of the Jordan sandstone at Lanesboro, with a remarkable concretionary structure, the concretions of which vary from a few inches to nearly a foot in diameter. The St. Lawrence limestone, Jordan sandstone and Shakopee limestone underlie the St. Peters sandstone and correspond to the Lower Magnesian limestone.

9. *Révue de Géologie* of Messrs. Delesse and Lapparent. Vol. xii for 1873 and 1874. 224 pp. 8vo. 1876. (P. Savy, éditeur).—A very convenient volume for the geologist, posting up the new facts and discoveries in lithological, stratigraphical and dynamical geology. We cite from it the following observations:

M. Gérardin has shown that the waters of subterranean streams, feeding artesian wells, contain no oxygen, as Péligot had before shown to be true of the water of Grenelle.

According to M. Ed. Jannettaz, the conductibility for heat of slaty rocks is much the greatest in the direction of the slaty structure. Thus the ratio is in a talcose slate (a hydromica slate?) from the United States 2·007; in argillyte (phyllade) 1·988; mica schist from Aurillac (Cantal) 1·82; in a ferruginous talc slate (hydromica slate?) making part of the itacolumites of Guyanne, 1·87; an argillyte of Angers, 1·6.

M. Cossa has observed that gneiss, granite, trachyte, basalt are decomposed more rapidly by water holding gypsum in solution than by pure water. Sæmann and Guyerdet have found that dolomite is easily decomposed by the same solution aided by a current of carbonic acid.

10. McCOY, *Paleontology of Victoria:* Geol. Surv. of Victoria; Decade III. 40 pp. roy. 8vo. Melbourne. (London: Trübner & Co.).—This decade contains descriptions and figures of remains of *Thylacoleo carnifex*, of some trilobites (species of Phacops, Forbesia, Lichas, Homalonotus), and of various Mollusks.

11. *Report on a Survey of a line to connect the waters of the Neuse and Cape Fear River in North Carolina, and of a line to connect the waters of Norfolk Harbor in Virginia, with the waters of Cape Fear River at or near Wilmington in North Carolina;* by Mr. S. T. ABERT, U. S. Engineer. Engineer Dept. Senate Ex. Doc., 44th Congress, No. 35.—This Report contains much valuable matter on the physical features of the coast region of North Carolina and Virginia, and of the changes which have been and are still going on there as to the limits and depths of the Sound, and the extent and outline of the sea-made lands, and on the origin of those changes.

12. *Mines and Mineral Statistics of New South Wales*, compiled by direction of the Hon. John Lucas, M.P., Minister for Mines. 252 pp. 8vo, with maps and sections. Sydney, 1875.—Besides mining statistics, this volume contains much of geological interest. It includes an essay on the sedimentary formations of the country, by Rev. W. B. Clarke, and notes on the Iron and Coal deposits of Wallerawand and on the diamond fields, by Prof. Liversidge.

13. *Recently formed crystallized minerals of the thermal spring at Bourbonne-les-Bains.*—Brief notices of Daubrée's examinations of the remarkable mineral transformations at Bourbonne-les-Bains have been given in volume x of this Journal, at pages 228 and 391. They were from abstracts of his communications to the Académie des Sciences in 1875, in the Comptes Rendus, lxxx, 461, 604 and lxxxi, 182, 834, 1008. The completed memoir has recently been published with some additions, and is issued as a pamphlet of 48 pages, by Dunod, Paris. It is a thorough discussion of the characters, conditions of occurrence, and modes of origin, of the several species, together with many valuable suggestions as to the bearing of the various facts on problems in geology. We cite the following points, not alluded to in the previous notices. The minerals derived from the action of the water on bronze objects (medals, etc.) include, besides those mentioned, also cuprite, chrysocolla, oxyd of tin and melaconite; and those from the action on lead tubes, cerussite (carbonate of lead). Daubrée remarks that while the copper had formed sulphids, the tin of the bronze had changed to the oxyd, which is its usual condition in metallic veins. Cuprite (oxyd of copper) was found in octahedral crystals in a tube of bronze, along with melaconite and chrysocolla. One of the specimens of phosgenite was associated with crystals of anglesite and had the cubic form of galenite. Oxyd of lead or litharge is still another of the lead products.

The iron found in the baths has in some places given rise to a hydrous silicate of iron, gelatinizing with acids, as had been observed by Daubrée also at Plombières. Vivianite is another of the iron minerals.

In addition to the zeolites, chabazite, and harmotome, there is one in regular hexagonal prisms which Daubrée refers with a query to the species *chalcomorphite*. Still other species are aragonite and calcite, and an earthy hydrous alumina silicate, related to halloysite or the material known as *Savon de Plombières*.

The whole number of crystallized species found to have been formed in the bottom of the old Roman well is at least twenty-four. Daubrée remarks that they may be looked upon as results of experiment although the experiments have been in progress through twenty times the duration of a human life. The water contains only neutral salts in solution, and has a temperature from 58° to 68° Centigrade. It has made different compounds according to the different materials that were bathed by it; and these are of so various kinds as to illustrate well the association of minerals in some metallic veins. The changes were produced at

Bourbonne, as they were also at Plombières, within eight meters of the surface, and at a temperature but little elevated; how great, then, asks Daubrée, must be the transformations we should witness if we could descend to the deeper parts of the conduits of thermal waters; and what the changes that must have gone on at all times through the waters penetrating the earth's deeper rocks and fissures.

14. *Further notes on inclusions in Gems*, by ISAAC LEA, LL.D. 11 pp. 8vo. Philadelphia, 1876.—Dr. Lea, in continuation of his former paper on this subject, describes cavities and minute crystals observed by him in tourmaline; of a cubic form and including a fluid, in an emerald; blue, and 4-sided, in iolite; tubular cavities, with a cubic crystal with fluid in one cavity, in blue corundum of North Carolina; minute acicular crystals in corundum of Delaware Co., Pa., producing a bronze-like luster; and other results of his observations. The paper is accompanied by a lithographic plate.

15. *Geological Map of Europe.*—A small colored geological map of Europe showing the distribution of stratified rocks has been recently published in Petermann's Geographische Mittheilungen. It was prepared by Habenicht, and is an excellent map for one of the size—12½ by 15½ inches.

16. *New Minerals: Ihleite, Friedelite.*—Prof. Schrauf has announced a new mineral under the name *Ihleite*. It occurs as a yellow efflorescence on the graphite of Mugrau, Bohemia. Its composition is expressed by the formula $Fe_2S_3O_{12}+12H_2O$. (Anzeiger, Ak. Wien, March, 1876.) *Friedelite* is a hydrated silicate of manganese described by M. Bertrand. Its characters are as follows: Rhombohedral. Cleavage eminent, normal to the vertical axis. Two varieties, one with saccharoidal structure, the mass made up of hexagonal lamellæ, with perfect cleavage, and the other very compact, with the cleavage scarcely visible. Double refraction energetic, axis negative. H.= 4·75, G.= 3·07. Color rose-red; streak pinkish-white. Transparent in thin fragments, in the mass translucent. Composition, the mean of several analyses: SiO_2 36·12, MnO 53·05 (FeO tr), MgO, CaO 2·96, H_2O 7·87=100. Both varieties mentioned give the same composition; in fact they pass into one another. M. Bertrand writes the formula $4MnO, 3SiO^2, 2H^2O$ ($Mn_4Si_3O_{12}+2aq$), and remarks that it seems to be somewhat similar to hydrotephroite (Dana, Min. 1868, p. 260). B.B. fuses easily to a black glass; in the closed tube gives water. Dissolves in hydrochloric acid with the separation of gelatinous silica. With the fluxes reacts for manganese.

Found at the manganese mine of Adierville, valley of Louron (Hautes Pyrénées).—*C. R.*, May 15, 1876. E. S. D.

17. *Analcite not isometric.*—Prof. Schrauf, (l. c.) from an examination of analcite crystals from Friedeck, Bohemia, concludes that the species (like leucite) cannot be referred to the isometric system. The simplest crystals show evidence of repeated twinning, and the angle between the cubic planes is 89° 30′, implying the

existence of a dome as twinning plane, with an angle of 44° 45′, and giving the axial ratio 1 : 0·991. Irregularities in the optical properties of analcite were observed by Brewster. E. S. D.

18. *Angewandte Krystallographie* (*Ausbildung der Krystalle, Zwillingsbildung, Krystallotektonik*) *nebst einem Anhange über Zonenlehre*, von A. SADEBECK. 284 pp. 8vo, with 23 plates. Berlin. 1876.—The present volume forms properly the second part of the Elements of Crystallography (of G. Rose) published by Prof. Sadebeck in 1873. The object of the work is to describe crystals as they actually appear in nature, not the ideal forms which are of only theoretical existence. The special subjects considered are: 1. hemimorphism and pseudo-symmetry, the latter arising from the natural distortion of crystals in certain axial directions; 2. twins, including their explanation theoretically, and also an enumeration of all the methods or laws of twinning observed in the different systems; 3. the method of growth of crystals, showing how each individual is gradually built up of minute sub-individuals, and thus giving an explanation of many irregularities observed not only on the surfaces of the planes, but also in the interior of crystals. This last subject is one of great theoretical interest, and in the discussion of it the author has introduced much matter which is new obtained from his own extensive researches; it is elucidated by many excellent figures. The last chapter of the work discusses the subject of zones, considered particularly by means of the Quenstedt method of projection.

E. S. D.

19. *New Journal devoted to Mineralogy and Crystallography.*—Professor Groth, in a letter to the editors dated Strasbourg, May 28th, 1876, announces the commencement of a new Journal for special mineralogy. The plan of this Journal embraces the following subjects:—theoretical, physical and chemical crystallography; investigations in regard to artificial crystals; monographs of single minerals especially in relation to crystallography; memoirs on the chemical composition and artificial production of minerals, descriptions of their methods of occurrence, their determination under the microscope; in a word the Journal will cover the whole field of mineralogy, with the exclusion of geology. The leading mineralogists of Germany and Austria are all interested in the project, and it is desired that those of other countries should also lend their support so that the Journal may gradually assume an international character. In addition to the original papers it is proposed to include references to mineralogical work wherever published. There are to be from six to eight numbers during the year, appearing every six or eight weeks with the exclusion of the vacation months. The chief editorial duty will be performed by Prof. Groth, with the especial coöperation of Prof. G. vom Rath of Bonn, and Prof. Klein of Heidelberg. The publisher is Engelmann of Leipzig.

The plan deserves the hearty support of all interested in this department of science.

III. Botany and Zoology.

1. *The Oaks of the United States;* by Dr. George Engelmann. Reprinted from the Transactions of the Academy of Science, of St. Louis, Missouri, vol. iii, no. 3. 1876.—Only 20 pages; but they are wholly to the purpose, and contain the leading results of the long and close scrutiny which Dr. Engelmann has given to this vexed genus of trees. The paper begins with an account of the deceptive character of the common western oaks, as exemplified by the common scrub oak of the Rocky Mountains, basing his narrative upon his personal observations of its forms in the valley and on the bordering bluffs and precipices, where the Arkansas leaves the mountains at Cañon City, Colorado. Here, at different heights and exposures, he found *Quercus Gambelii* (*Q. stellata*, var. *Uthensis*, DeC.), *Q. Gunnisoni*, *Q. undulata*, described by Torrey long ago from this district, *Q. pungens* of Liebman, in part, *Q. oblongifolia*, *Q. grisea*, and *Q. Drummondii* of Liebman,—"in herbarium specimens all distinct enough, but, looking around us, the very abundance of material must shake our confidence in our discrimination [since] within the compass of a few hundred yards we find not only the forms above distinguished, but numbers of others, neither the one nor the other, but which are intermediate between them, and clearly unite them all as forms of one single, polymorphous species. If one oak behaves thus, why not others? Thrown upon a sea of doubt, what can guide us to a correct knowledge?"

Dr. Engelmann reviews the principal characters, one by one, to settle their relative value; and, in doing so, brings out the main general results of his protracted and patient investigations in this field. The trunk, as to size attained, while it gives character to eastern species (only the southern live oak occurring both as large tree and shrub, and equally fruitful in both forms), fails on the Pacific slope to be a specific distinction. "Examining the *bark*, we at once become aware of the fact that the popular distinction between 'white oaks' and 'black oaks' is based on correct observation. The paler, ashy-gray bark of the former, and the darker or often nearly black color of the latter, correspond with the essential characters, and mark the two principal groups of our American oaks. The bark of the white oaks is inclined to be scaly or flaky, that of the black oaks is usually rougher and deeply cracked or furrowed." "Moreover, the *wood* of the white oaks is tougher, heavier, and more compact; is the only oak wood fit to be used by the wheelwright or cooper, and is, for their purposes, unsurpassed. The wood of the black oaks is brittle and porous, makes poorer fire-wood, and in barrels holds only dry substances." Dr. Engelmann states that, "instead of making narrower and narrower rings as they grow older, the oaks either hold their own, the annual rings being as wide in age as in youth, or they grow more rapidly after the first 50, 100, or even 150 years of their existence."

The winter buds give characters in some species. As to the shape of the leaves, so extremely variable, it is remarked, "that those oaks, which in the perfect state have deeply lobed or pinnatifid leaves, show in young shoots and on adventitious branchlets less divided or even entire leaves; while, singularly enough, the oaks whose leaves in the adult tree are entire, or nearly so, often have on the young shoots dentate or lobed leaves."

The vernation of the leaves, although more commonly conduplicate, both in white and black oaks, furnishes other types, which Dr. Engelmann has first brought into prominent view, and finds of great account in distinguishing allied species and doubtful varieties, and in unravelling intricate questions of hybridity or affinity. The nature of the down on young leaves may also be turned to use. The venation occasionally enables easily confounded species, such as *Q. agrifolia* and *Q. Wislizeni*, to be distinguished even in sterile branchlets.

The persistence of the leaves is a good character in some species, while in others it is of no account. The leaves of some oaks persist even to the third year. "Only such oaks ought to be called evergreen which retain the greater part of their old leaves, at least until the new ones are fully grown."

In the male flowers the size and number of the anthers furnish good distinctions, being small and mostly 5 to 10 in the white oaks, four or sometimes 5 to 6 and larger in the black oaks; the pubescence of the anthers distinguishes a few species, while their cusp is variable in several. The female flowers distinguish the principal groups, especially the styles, which in the white oaks are sessile or nearly so; in the black oaks always on longer and spreading or recurved styles. The annual or biennial maturation of the acorn, first indicated by Michaux, and the persistence and position of the abortive ovules, indicated by Alph. DeCandolle (in white oaks at the base, in black oaks near the tip of the perfect seed), and the scales of the acorn cup (thick and knobby in white, thin and membranaceous in the black oaks), are likewise noted. The comparatively thin shell of the acorn in white oaks is dark and smooth within, or rarely pubescent; in the black oaks the shell is thicker and lined with a silky down.

All these matters relate to the true oaks (section *Lepidobalanus*), with scaly acorn-cups, pendulous male catkins wholly apart from the solitary or distant female flowers. But in California we have, in *Q. densiflora* a representative of the otherwise Asiatic subgenus, *Androgyne*, "in many respects more a chestnut than an oak; for it has, just like the chestnuts, dense-flowered and erect male spikes, 10 stamens to each flower, very small anthers on long filiform filaments," female flowers crowded at the base of the male catkins, linear pointed stigmas, and a spinose cup, which, however, is that of an oak rather than like the prickly involucre of the chestnut.

The paper continues with a systematic enumeration of the 38 recognized species, and notes are appended to about half of them.

Finally, hybrid oaks are discussed; and six well determined ones are enumerated as known to the writer, three of which have been described as species, namely: *Q. Leana*, *Q. tridentata*, and *Q. sinuata*. One parent of four of these hybrids is *Q. imbricaria*; of the other two, *Q. cinerea*. The fact that some species of a genus are more prone to hybridize than others—which is also true of *Verbena*—is curious. Most botanists will learn with some surprise that *Q. heterophylla* of Michaux is received, not as a hybrid, but as a well-marked species, of the *Phellos*, *laurifolia*, and *aquatica* group. Dr. Engelmann's six real hybrids are all of the Black oak group: this group never crosses with White oaks; and no hybrid of the latter group is known to our author. The black oaks are now unknown in Europe; but we learn that they existed there, along with white oaks, in the tertiary period.

It must be difficult to discriminate between hybrids and intermediate forms of variation where the usual character, the sterility of the hybrid, is wanting, "and where we have nothing to rely on but the rarity and individuality of a form that seems to stand intermediate between two well established species which occur in its neighborhood, and which could be considered its parents. This is just the case in Oaks. All the supposed hybrids are abundantly fertile, and those of their acorns that have been tested have well germinated; in fact, as far as I know, no difference in fertility or germinating power between them and the acknowledged species has been discovered. The seedlings of such questionable individuals do not seem to revert to a supposed parent, a sport of which they might claim to be, but they propagate the individual peculiarities of the parent--'come true,' as the nurserymen express it. At the same time it is a remarkable fact, that, notwithstanding their fertility, they do not seem to propagate in their native woods. We may properly ascribe this to a lesser degree of vitality in the hybrid progeny, which causes them to be crowded out in the struggle for existence." There is another reason, to us a more probable one. The hybrid tree, when isolated in cultivation, is likely to self-fertilize and so be continued in its progeny; but in its native forest, surrounded and dominated by its two parents, its female flowers will almost inevitably be fertilized by the pollen of one or the other of them and so brought back in the progeny to that species. Indeed a single tree, so situated, practically has almost no chance at all of perpetuating its kind. A. G.

2. *M. Gristave-Adolphe Thuret; Equisse Biographique;* par M. Ed. Bornet.—This is the title of an article in the latest number of the *Annales des Sciences Naturelles*, an interesting and worthy tribute by Dr. Bornet to the director and companion of his studies and researches, to whom is left the sacred duty of completing them, so far as possible. To the full biography is appended a catalogue of M. Thuret's scientific publications. The best and fullest notice of Thuret in the English language is one by Dr. Farlow, of Harvard University, contributed to Trimen's Journal of Botany at the beginning of the year. A. G.

3. *Fragmenta Phytographiæ Australiæ, contulit Liber Baro* FERDINANDUS DE MUELLER. Vol. IX. Melbourne, 1876.—This ninth volume bears testimony to the untiring industry, zeal, and ability with which Dr. Von Müller keeps up his investigations into the botany of the adopted country for which he has done so much in various ways; and his *Descriptive Notes on Papuan Plants*, and other publications upon the botany of the Pacific Islands, show how, from his vantage ground, he widens the already ample field, making the most of opportunity, ever active himself, and inciting and directing the activity and advantages of others. A. G.

4. *Flora Brasiliensis*, ed. AUG. GUIL. EICHLER.—The *Compositæ* of this great flora are undertaken by Mr. J. G. Baker of Kew, a new hand in this order, but capable of doing good work in this department, as well as among the Monocotyledons. Fascicle 62, issued in 1873, contained the *Vernoniaceæ*, with 50 plates. Fasc. 69, issued early in the present year, contains the *Eupatoriaceæ*, with 52 plates. The two fascicles compose vol. vi, part 2, with 398 pages of letterpress and 102 plates. The enlightened and active-minded emperor, Dom Pedro, may be well pleased at having such a flora of his empire, and at the prospect of its early completion. A. G.

5. *The Forest: Products of Michigan at the Centennial Exposition;* by Prof. J. W. BEAL, of the State Agricultural College.—A pamphlet of 16 pages, 8vo, giving an account, not only of the collection exhibited, but of the trees of the State, both the common and the rare species, their characteristics and their uses. There is a record of the larger trees of each species known in Michigan, which is now interesting and may hereafter become more so, if the individual trees are well identified. As to high trees: "At Clam Lake an old lumberman informed me that he could furnish spars of pine 175 feet long and not over two feet through at the butt. He had cut them 200 feet long." A. G.

6. *Contributions to the Flora of Iowa*, a catalogue of the Phænogamous plants; by G. C. ARTHUR. 1876.—A neat catalogue; with an appendix containing descriptions—generic and specific—of the species detected in Iowa which are not in Gray's Manual, twenty or so in number, and good notes upon some others. A. G.

7. *Locust invasion of* 1874.—Mr. G. M. Dawson has published a paper in the Canadian Naturalist on the Locust invasion of the country north of the United States. He remarks that they appeared in Manitoba in 1818, and from there have caused serious destruction in ten years, and been observed fifteen seasons. In 1874 none were hatched from the egg east of the 103d meridian, but in Dakota, some were hatched as far east as 99° W. The invasion in 1874 began late in June and continued during July, the direction of flight being between east and south. The most astonishing fact "is the fixed determination of the swarms to travel in a certain direction, and the wonderful instinct which leads them to a wind favoring their intention." One year they

reached the shores of the Lake of the Woods, long. 96° W. They do not eat sorghum or brown corn, and the *Leguminosæ* (pea and bean family) are decidedly disliked, while potatoes, tomatoes, and beets are usually exempt. Mr. Dawson asks whether this dislike for *Leguminosæ* may not account for the existence of a vast number of such plants on the western plains.

8. *United States Geological Survey of the Territories.* Volume X, *Monograph of the Geometrid Moths*, by A. S. PACKARD. Washington, 1876. 4to, with 13 Plates.—This is the first complete treatise on the North American species of the families of moths which Dr. Packard, following Guenée, calls *Phalænidæ*. The work is of extreme value in the present state of our knowledge of this group, for it presents us with a compilation of the literature, and from its original matter it must remain a standard of reference on the subject. Between three and four hundred species are described in the present work, while the author estimates the probable number of species occurring over our territory as "nearly a thousand." In the allied family of *Noctuidæ* we have catalogued nearly twelve hundred species, and estimate the number of species at over fifteen hundred. Dr. Packard's work is remarkable for the amount of labor expended on the generic and specific descriptions, which cannot be undervalued. The introductory chapters are of special interest, as also the concluding essay on geographical distribution. We miss an analytical table of the genera. In a work of this pretension it should not be wanting. The author finds occasion to prefer De la Guenée's work (Species Générales) to Lederer's on the moths. It is undoubted that Guenée's work on the *Phalænidæ* is superior to his work on the *Noctuidæ*. In the latter family we have found his genera largely inconsistent, and throughout important characters (e. g. the vestiture of the eyes, the armature of the tibiæ, etc.,) are totally neglected. We place his systematic work as undoubtedly lower than Lederer's, who stands at the head of all writers on the subject of genera in the two great families of the moths above mentioned. To Guenée we are disposed to give the greatest praise for his descriptions of species. Dr. Packard begins his work with the lower genera, ascending to the higher; so that the usual arrangement of the material is reversed. In the absence of a similar treatment of the other families of Lepidoptera, this change is a disadvantage to the student in arranging his collections.

In the synonymy Dr. Packard adopts the Hübnerian genera, from the Tentamen, as Mr. Scudder has done with regard to the Butterflies and we have done in the *Noctuidæ* (List of the N. Am. *Noctuidæ*, 1874). No other course is open to the systematist. Dr. Packard is fortunate in having so large material as to be able to unite several species hitherto regarded as distinct (e. g. the species of *Drepanodes* and *Ellopia*); with regard to the species of *Ellopia* Dr. Packard says: "If I had had Mr. Grote's types alone of male *E. bibularia* and female *pellucidaria*, I should have regarded them as distinct." Perhaps in uniting *Endropia amœnaria* and *E. arefactaria* Dr. Packard may prove less fortunate. In the generic names adopted we find a few which will not stand. *Eu-*

gonia is preoccupied in the Butterflies. *Eutrapela* must be used for *Kentaria* and *Alciphearia*; *Chœrodes* for the genus called *Eutrapela* by Dr. Packard. The plates are worthy of great praise, and will bear the most critical inspection. The numerous general figures were drawn on stone by Trouvelot. Dr. Hayden is to be heartily congratulated on the publication of this volume, which reflects much credit upon his judgment and the scientific standing of the Geological Survey, and Dr. Packard deserves the gratitude of entomologists for his treatment of the subject. A. R. G.

9. *Tabulate Corals.*—Dr. G. Lindström, in a paper a translation of which is given in the Ann. Mag. Nat. Hist. for July, discusses with judgment the relations of the tabulated corals. He refers the *Millepora* to the Hydroids (adopting Agassiz's conclusion); *Favosites* to the Poritinæ (following Verrill) with *Rœmena*, *Striatopora* Hall, etc.; *Heliolites*, *Halysites*, *Lyellia* E. & H., *Plasmopora* (with *Propora*) E. & H., *Calapœcia* Billings, *Thecostegites* E. & H., to the Heliolitidæ; *Heliopora* and *Polytremacis* to the Alcyonaria; *Chætetes*, *Monticulipora*, *Dania*, *Stellipora*, *Alveolites* in part, *Fistulipora* in part, to the Bryozoa: *Pocillopora* (following Verrill) to the Oculinidæ, with, probably *Seriatopora*; *Columnaria*, to the Cyathopyllidæ; *Fletcheria* and *Michelinia* to the Cystiphyllidæ; *Syringopora*, to the vicinity of Lithostrotion and Diphyphyllum.

10. *Rafinesque's Ichthyologia Ohiensis.*—Dr. D. S. Jordan has a paper giving the equivalents in modern nomenclature, so far as were ascertainable, of the species of fishes named by Rafinesque, in the Bulletin No. 3 of vol. iii of the Buffalo Society of Natural Sciences. The same number contains also a check-list of the fishes of the freshwaters of N. America by Dr. Jordan and H. E. Copeland, and a synonymic list of the Butterflies of N. America, north of Mexico, by S. H. Scudder.

11. *Synopsis of American Wasps*; by Henri de Saussure of Geneva, Switzerland. *Solitary Wasps.* Smithsonian Miscellaneous Collections, No. 254. 386 pp. 8vo, with 4 plates. Washington, December, 1875.

12. T. Lyman, *on Ophiuridæ and Astrophytidæ* collected by the Hassler Expedition and Dr. Wm. Stimpson. Illustrated Catalogue of the Mus. Comp. Zool. at Harvard College. No. VIII. 34 pp. 4to, with five excellent plates.

13. *Bulletin of the U. S. National Museum, published under the direction of the Smithsonian Institution*, No. 4. Birds of Southwestern Mexico, collected by F. E. Sumichrast, prepared by G. N. Lawrence. 56 pp. 8vo.—No. 5. Catalogue of the Fishes of the Bermudas, by G. Brown Goode. 82 pp. 8vo. Washington, 1876.

Catalogue of the Stalk- and Sessile-Eyed Crustacea of New Zealand, by Edward J. Miers, F.L.S., Assist. Zool. Dept. Brit. Mus., Colonial Museum and Geological Survey Department, James Hector, M.D., Director. 136 pp. 8vo, with 3 plates. London, 1876.

Catalogue of the Birds of Kansas, by F. H. Snow. 3d ed. 14 pp. 8vo. Nov., 1875.

List of Skeletons and Crania in the Section of Comparative Anatomy of the U. S. Army Medical Museum.

IV. Miscellaneous Scientific Intelligence.

1. *On Oceanic Circulation;* by Wm. B. Carpenter.—The very decided expression of opinion on the part of Professor Wyville Thomson, to which currency is given in the *Athenæum*, against the doctrine of "a general vertical circulation of the water of the ocean, depending on differences of specific gravity," is far from being decisive of the question; and might, perhaps, have been advantageously withheld, until my friend should have learned, on his return home, what progress has been made towards its solution by physical inquiry, during his three and a half years' absence.

If he had been present at the Bristol meeting of the British Association, he would have learned, from Mr. Froude's experimental confirmation of the "wave-line theory" of our greatest mathematical physicists, that *friction of water upon water* is so small an obstacle to its movement, that it may be practically disregarded; so that very small disturbances of the static equilibrium of ocean water—whether produced by diversities of temperature, or by alterations of its salinity—*must* give rise to a movement tending to its restoration, without the necessity of any appreciable "gradient." And he might have further received from Mr. Froude (as I had the advantage of doing) the confirmatory evidence on this point furnished by his extended observations on harbors, lochs, and fiords; to the effect that wherever the specific gravity of the surface-water of any such inlet of the sea is reduced by a river efflux, an under-current of sea-water is forced inwards by the excess of pressure outside. At the same meeting, my friend would have heard Sir William Thomson, commenting upon Mr. Croll's asserted disproof of the "gravitation theory," give the full weight of his great authority to the doctrine (originally propounded by Lenz in 1845) of a vertical oceanic circulation sustained by opposition of temperature; Sir William emphatically declaring it to be a matter "not of opinion, but of irrefragable demonstration."

If, again, Prof. Wyville Thomson had enjoyed the advantage of meeting the distinguished foreign physicists, Prof. Möhn, of Christiania, and Prof. Buys Ballot, of Utrecht, who recently came over to attend the Meteorological Congress in London, he would have found them entirely satisfied of the truth of the gravitation doctrine; and would have received from the former the following remarkable exemplification of it:—

Outside the coast of Norway, there is a deep channel, along which a flow of glacial water can be traced southward as far as the Cattegat. This flow cannot possibly be accounted for by any "excess of evaporation over precipitation;" for it proceeds towards an area that receives a large river efflux from the Christiania fiord, as well as the efflux of weakly-saline water from the Baltic. And it is unhesitatingly attributed by Prof. Möhn to the relative excess of downward pressure over the northern end of the trough, constantly maintained by the reduction of downward pressure over its southern extremity, which results from the admixture of fresh water.

Until, therefore, Prof. Wyville Thomson shall have been able to disprove these results of combined theoretical and practical research, by showing that differences of specific gravity, produced by differences either of temperature or of salinity, will *not* produce movements in oceanic water tending to the restoration of its disturbed equilibrium, I venture to affirm that his *dictum* will not find acceptance with the physicists who have most carefully studied the question. His present doctrine, that the underflow of polar water is an indraught due to "the excess of evaporation over precipitation," is as much opposed to physical theory as his former doctrine that the indraught is due to the sweeping away of equatorial water by the trade winds, which was unhesitatingly pronounced untenable by the distinguished physicists who discussed it at the last Edinburgh meeting of the British Association. For they were unanimous in affirming that a removal of surface-water from any area will be replaced by a surface inflow (where this is unrestricted), rather than by an indraught from beneath. And it seems to me no less in contradiction to the facts of the case. For the Challenger observations have afforded the fullest confirmation of the two fundamental positions of Lenz's doctrine:—(1) The near approach of polar water to the surface under the equator; and (2) The marked inferiority in the salinity of equatorial surface-water as compared with that of the tropics. The first of these facts shows that the updraught of polar water is nowhere so strong as it is under the equator; the second proves that, in some way or other, the loss by evaporation in the equatorial area is more than replaced, so that it can occasion no such updraught.

These two facts were considered, by one of the ablest physicists of his time, as capable of no other explanation than that afforded by the doctrine of a vertical oceanic circulation, of which the *primum mobile* is the excess in the specific gravity of polar water, causing its continual descent and a complemental ascent in the equatorial zone.

I am far from affirming that "excess of evaporation over precipitation" has no influence in producing movements of ocean water; on the contrary, I have shown that it is the *vera causa*, not only of the surface in-current, but of the outward under-current, of the Gilbraltar Strait. And it is, doubtless, one of the agencies at work, whenever it operates strongly over a localized area.

The problem of Oceanic Circulation, in fact, is rendered one of great complexity by the number of such agencies, and the great variety in the local conditions under which they respectively operate. And since, in the discussion of the vast body of valuable observations collected by the Challenger, it will be of the first importance that the principles on which that discussion is to be based should be settled by the highest authorities in physical science, I trust that at the ensuing meeting of the British Association at Glasgow, an opportunity may be provided for a full and free debate, in which Prof. Wyville Thomson, Mr. Croll, and I, may set forth our respective views in friendly antagonism, and

may submit them to the judgment of the distinguished physicists who will doubtless be there assembled.

To such a judgment I pledge myself implicitly to bow; no one being better aware than myself of the disadvantage under which I labor in possessing no more than an elementary knowledge of physical doctrine.—*Athenæum*, May 13.

2. *Reclamation.—Letter to the Editors, from Mr. George Davidson, U. S. Coast Survey*, dated San Francisco, March 7, 1876.—In the March number of your Journal (No. 63, vol. xi,) Article xxix, by Professor Lovering, the statement is made that "the late Professor Winlock [in February and March, 1869] sent electrical signals from Cambridge to San Francisco, and thence by other lines to Canada, and back again to Cambridge, over a loop of wire measuring 7200 miles."

Professor Winlock and I were always in full accord in this and other matters, and I am sure he never made the above claim. On the contrary, he gave me full credit for the inception of the experiments, and the successful determination of the wave time over a loop of wire of 7200 miles with the batteries and repeaters in line. The experiment was a necessary consequence of the telegraphic longitude operations of the United States Coast Survey between Cambridge and San Francisco.

Moreover, the experiment was not made at Cambridge; it was made by me in the Coast Survey Observatory at San Francisco, and the loop was made by Professor Winlock at Cambridge. The signals were transmitted from my clock to Cambridge, and to other stations and back; and as Cambridge did not have the necessary instrument for such a record, Professor Winlock devised a means of sending and receiving clock signals over a single wire; unfortunately the cable across the Golden Gate broke after passing the first series, and no more were undertaken.

The whole work is fully detailed in the records of the Coast Survey, and, by permission of the Superintendent, the results and *modus operandi* were verbally communicated by me to the California Academy of Sciences.

If, however, the details of my work and of Professor Winlock's device are of any interest to experimentalists, I can readily supply them from the original memoranda.

3. *Men of Science, from abroad, at the U. S. International Exhibition.*—No occasion has before drawn together so many distinguished men of science from abroad, in various departments, as the Centennial Exhibition at Philadelphia. Without attempting to enumerate all whose names might properly be mentioned in this relation, we recall, from Great Britain, Sir WILLIAM THOMSON, the well-known physicist who is President of the Judges on the XXVth Group—Instruments of Precision and Research; Sir JOHN HAWKSHAW, the eminent engineer who was last year President of the British Association; Sir CHARLES REED, President of the XXVIIIth Group of Judges—for Education and Science; Capt. DOUGLAS GALTON, President of the Judges under the XVIIIth Group—Railway Plans, etc.; Mr. ISAAC LOWTHIAN BELL, the

most eminent iron metallurgist in Great Britain, and author of the well-known treatise on the 'Chemistry of the Blast Furnace,' President of the Judges of Group I—Minerals, Mining, Metallurgy, etc.; Dr. WILLIAM ODLING, Waynflete Professor of Chemistry in the University of Oxford, Secretary of the board of Judges on Group III –Chemistry and Pharmacy, etc.; from Sweden, Prof. ADOLF E. NORDENSKIÖLD, Prof. C. A. ANGSTRÖM, Polytechnic Institute, Prof. O. M. TORELL, Chief of the Geological Survey of Sweden, and RICHARD ÅKERMAN, of the Royal Swedish School of Mines, all from Stockholm, under whose immediate superintendence the excellent geological, mineralogical, and metallurgical display of Sweden, at the Exposition, has been made; from Russia, Major General AXEL GADOLINE, an eminent Russian engineer, and Prof. L. NICHOLSKY, Mining Engineer and adjunct Professor at the Mining School of St. Petersburg, who is in charge of a systematic collection of Russian minerals—the only systematic mineral collection in the Exposition; from Germany, Dr. WEDDING, Royal Prussian Counsellor of Mines, Dr. RUDOLPH VON WAGNER, the well-known Editor of Wagner's Jahresbericht, and Dr. G. SEELHORST, of Nuremberg; from France, Mr. L. SIMONIN, J. F. KUHLMAN (fils), M. E. LEVASSEUR, and M. EMILE GUIMET, of Lyons; from Italy, Prof. EMANUEL PATERNO, of Palermo; from Mexico, MARIANO BARCENA, the mineralogist.

The Emperor of Brazil, without claiming the position of a man of science, manifests the most intelligent and cultivated understanding of all that is most worthy of notice in scientific methods, his enquiries extending to everything which should interest the Head of a great Continental Empire.

Prof. Nordenskiöld on July 1st, left on his return, to join a new expedition of discovery to the seas of Northern Siberia.

4. *Connection of the Caspian and Black Seas.*—It is reported that the connection of the Caspian and Black Seas by a canal, and a raising thereby of the surface of the Caspian—now below sea-level—is under consideration. The length of the proposed canal would be 240 kilometers, and the width to the eastward about 170 yards, and to the westward about 110 yards. A second project, complementary to this, is the junction of the Don and Volga, and the turning thus into the Caspian of the larger part, if not the whole of the former river. The project has been proposed to the Russian Government by an American company.—*L'Institut*, 28 *Juin*.

5. *Geographical Survey of the State of New York.*—The board appointed by the act of the last Legislature to make a trigonometrical survey of the State, have adopted resolutions to the effect that an officer shall be appointed, with the title of Director, whose duty it shall be to prepare and submit to the consideration of the Commission plans for conducting the survey, with estimates thereof, and under the direction of this board to organize, superintend, and manage the work required for carrying out such of these plans as shall be approved; that the Director shall nominate suitable assistants for the required duties of the survey, and that none shall be appointed unless nominated by him; that the Di-

rector and all other officers shall hold office during the pleasure of the board; that the salary of the Director shall be $4,000 per annum, including expenses. Under the first resolution the board proceeded to choose a Director, and Prof. James T. Gardner, at present Secretary of the American Geographical Society, was elected.—*N. Y. Times*, July 13.

6. *Appalachia*, June, 1876, vol. I, No. 1, 62 pp. 8vo. Boston: A. Williams & Co. Published for the Appalachian Mountain Club.—The Appalachian Mountain Club was organized in 1876 "for the advancement of the interests of those who visit the Mountains of New England and adjacent regions, whether for the purpose of scientific research or summer recreation." The Club proposes to carry on a systematic exploration of the regions referred to, both topographical, geological, and artistic. The President is Prof. E. C. Pickering, Vice President S. H. Scudder, and Secretary J. B. Henck, Jr., of the Technological Institute, Boston. The papers contained in this first number of the publications of the Club, are a Report on the Nomenclature of the White Mountains; an abstract of a paper on the "Atlantic System of Mountains," by C. H. Hitchcock; a day on Tripyramid, by C. E. Fay; on two new forms of Mountain Barometer, by S. W. Holman; a new map of the White Mountains (with a Map) by Mr. J. B. Henck, Jr.; on the East Branch of the Pemigewasset, by W. Upham; together with reports of the Councillors for the spring of 1876, containing suggestions of work proposed for the summer.

7. *American Association for the Advancement of Science.*—The 25th meeting will commence at Buffalo, N. Y., August 23. Members on arrival will find the Permanent Secretary at the Tifft House. By means of certificates, obtainable of the Permanent Secretary, at Salem, Mass., tickets at reduced prices may be had on the following railroads: Erie, Grand Trunk, Canada Southern, Great Western, Pennsylvania, Lake Shore and Michigan Southern, Cleveland, Columbus, Cincinnati and Indianapolis, New Orleans, St. Louis and Chicago.

8. *Elements of Physical Geography*, for the use of Schools, Academies and Colleges; by Edwin J. Houston, A.M., Prof. Phys. Geog., and Nat. Phil., Central High School, Philadelphia. 158 pp. sm. 4to, with many illustrations. Philadelphia, 1876. (Eldredge & Brother.)—An excellent text book well adapted for school instruction. The numerous illustrations are beautiful and include several colored maps.

9. *Proceedings of the Poughkeepsie Society of Natural Science*, vol. i. 42 pp. 4to.—This first number is occupied with an article giving the views of Mr. Charles B. Warring, in an article entitled "Studies upon the Inclination of the Earth's Axis."

10. *Transactions of the Kansas Academy of Science*, vol. iv. 62 pp. 8vo. Topeka, 1875.—This volume contains papers by Prof. W. K. Kedzie, on ozone in the Kansas atmosphere, and on the Nebraska hot bluff (hot through the oxydation of pyrite); G. E. Patrick, on the Kansas chalk, analysis of Kansas soils, and on Kansas salt; M. V. B. Knox, on Kansas Mammalia; G. F.

Gaumer, on the habits of some larves; W. Osburn, on the Cottonwood leaf-beetle; F. H. Snow, on the Rocky Mountain Locust, the larve and chrysalis of the Sage Sphinx, Catalogue of the Lepidoptera of E. Kansas (503 species), and Meteorological Summary for 1875. The meteorological summary states that the amount of rain (including snow) at Lawrence, Kansas (38° 58′ N., 95° 16′ W., at an elevation above the sea-level of 884 feet) was 28·87 inches, the same as for 1874, but 4·11 inches below the average rainfall of the last eight years.

11. *hkl.*—A new mineralogical society has been formed in England, styled the *hkl*, having Prof. Miller as its President.

Medical Statistics of the Provost Marshal General's Bureau. Compiled under the direction of the Secretary of War, by J. H. Baxter, A.M., M.D. Vols. I. and II. Thick 4to. 1875.

Principia or Basis of Social Science; by R. J. Wright. Second Edition. 542 pp. 8vo. Philadelphia, 1876. (J. B. Lippincott & Co.)

OBITUARY.

Porter Poinier, only son of Elisha B. and Frances A. Poinier, of Newark, died in New York city on Sunday afternoon, June 11th, aged 23 years. He had given himself to the study of Physics, and in the Polytechnic Institutes of Troy and Hoboken, he had thus early developed a very remarkable genius in the department of applied science. His studies had led him, with great success, into original investigations of heat as a force in nature, and his thorough and accurate and independent researches in this direction had attracted the favorable notice of the faculties under whom he studied. He attained to such important results as were found worthy of public notice, and he was engaged in the preparation and publication of an original work on the Dynamics of Heat, with the approval of his professors. His enthusiasm drank up his spirits, and utterly exhausted his physical force. Before he was aware, he was in the advanced stages of an incurable disease, and, while laboring to put his work through the press at Cambridge, he was pronounced beyond recovery. All his ardor in study was suddenly quenched by disease, and sadly he fell in the midst of his successes.

His very rare attainments and his extraordinary promise in the field of research had been brought to the notice of the Johns Hopkins University at Baltimore, and the day after his death, only too late for his noble ambition, came the certificate from the heads of the University, appointing him to a Fellowship in that institution. As a lecturer in the department of his special and successful study he had become familiar with the best French and German works in modern science, and his accuracy and perseverance and thirst for knowledge gave him promise of a very eminent future as a scientist. Such a young man, of unblemished morals, of pure and lofty aims, gifted with faculties of so high order, already attracting the attention of the learned, and laying down his life for truth as revealed in God's Book of Nature, trained, withal, to the highest of sciences in the written revelations, and searching for the truth of Christ, such a young man fills a large space and dies leaving a sad void. J.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

Drawn from nature by G. W. Hawes

Punderson & Cruse and New Haven, Ct.